(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 443 643 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 158(3) EPC

(43) Date of publication:
04.08.2004 Bulletin 2004/32

(21) Application number: **03771284.1**

(22) Date of filing: **23.07.2003**

(51) Int Cl.[7]: **H03H 9/25**, H03H 9/17, H03H 3/02, H03H 3/08

(86) International application number:
PCT/JP2003/009310

(87) International publication number:
WO 2004/012332 (05.02.2004 Gazette 2004/06)

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PT RO SE SI SK TR
Designated Extension States:
AL LT LV MK

(30) Priority: **31.07.2002 JP 2002222610**
16.07.2003 JP 2003198059

(71) Applicant: **Murata Manufacturing Co., Ltd.**
Nagaokakyo-shi Kyoto-fu 617-8555 (JP)

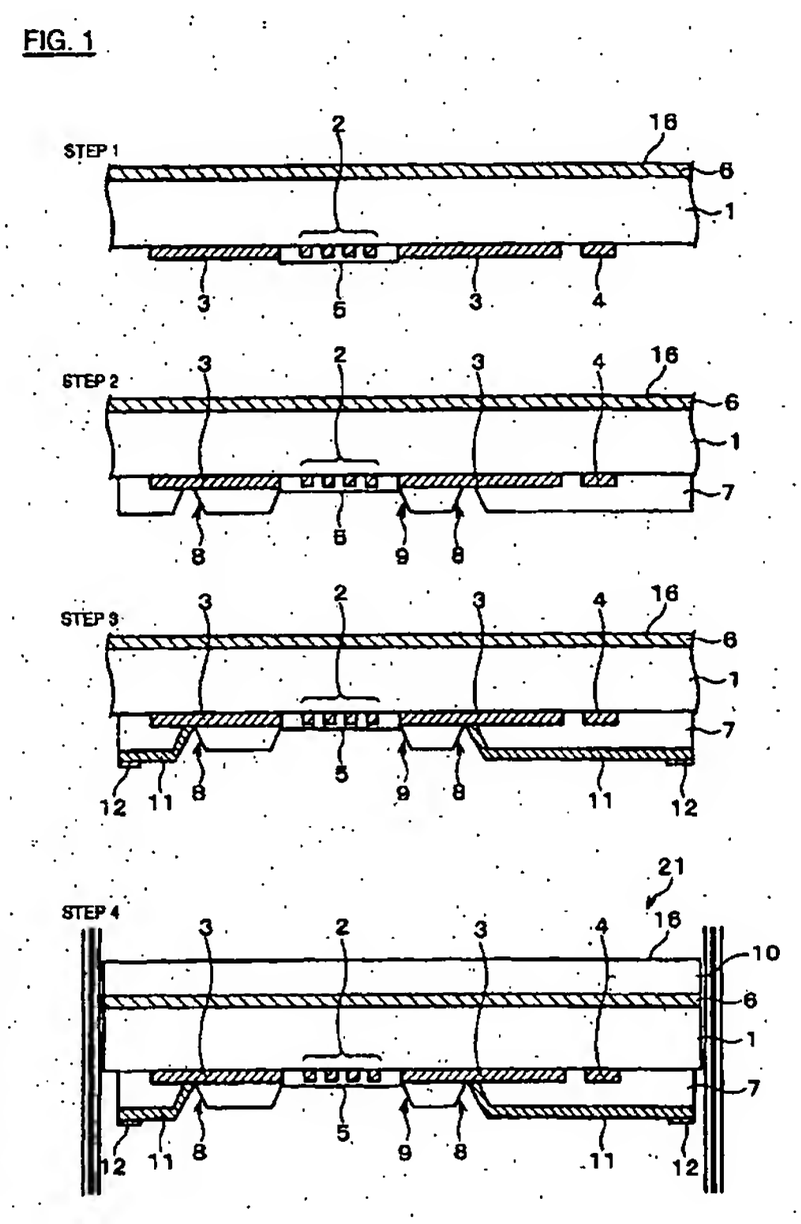
(72) Inventor: **KOSHIDO, Yoshihiro,**
c/o MURATA MANUF. CO., LTD.
Nagaokakyo-shi, Kyoto 617-8555 (JP)

(74) Representative: **Thévenet, Jean-Bruno**
Cabinet Beau de Loménie
158, rue de l'Université
75340 Paris Cédex 07 (FR)

(54) PIEZOELECTRIC COMPONENT AND METHOD FOR MANUFACTURING THE SAME

(57) The present invention provides a compact piezoelectric component in which degradation in the characteristic thereof is further suppressed, and a method for manufacturing the same. A SAW device 21 includes a SAW element 16 having an IDT 2 and a conductive pad 3 connected to the IDT 2 formed on a piezoelectric substrate 1; and an external terminal 12. The SAW device 21 also includes an insulating layer 7 having an exciting portion protective opening 9 serving as space for protecting a SAW-exciting portion including the IDT 2 and a conductive opening 8. The external terminal 12 is connected to the conductive pad 3 through a wiring 11 extending in the conductive opening 8.

FIG. 1



EP 1 443 643 A1

Printed by Jouve, 75001 PARIS (FR)

Description

Technical Field

[0001] The present invention relates to piezoelectric components such as surface acoustic wave devices and piezoelectric thin-film filters used for delay lines and filters or the like and a method for manufacturing the same. In particular, the present invention relates to piezoelectric components packaged in a chip size and a method for manufacturing the same.

Background Art

[0002] In recent years, a decrease in size and weight of electronic devices has caused a growing demand for multifunctional electronic components. In this circumstance, piezoelectric components, such as surface acoustic wave filters (hereinafter referred to as SAW filters) serving as SAW devices and piezoelectric filters including piezoelectric thin-film resonators, used for communication apparatuses such as portable phones are required to be decreased in size and weight.

[0003] A piezoelectric filter includes piezoelectric resonators arranged in a ladder pattern or lattice pattern. Each resonator includes an Si substrate having an opening or a recessed portion; and a vibrating portion formed by sandwiching the upper and lower surfaces of a thin-film portion having at least one layer of piezoelectric thin-film (comprising ZnO or AlN) formed on the opening or the recessed portion by at least a pair of upper and lower electrodes facing each other. Alternatively, the Si substrate may not include an opening or recessed portion, and space may be provided between the lower electrode and the Si substrate. In this type of piezoelectric filter, thickness longitudinal vibration generated at the vibrating portion is used. Therefore, space for vibration must be ensured and the vibrating portion must be protected against water and dust.

[0004] On the other hand, a SAW filter is formed by arranging interdigital transducers (hereinafter abbreviated as IDTs), each including a pair of comb electrodes comprising metal such as Al, on a piezoelectric substrate comprising quartz, $LiTaO_3$, or $LiNbO_3$. In such a SAW filter, vibrating space for the IDTs and a SAW-propagating portion on the piezoelectric substrate must be ensured, and the IDTs must be protected against water and dust.

[0005] In the above-described piezoelectric filter and SAW filter, a die bonding agent is applied to the bottom surface of a package comprising a ceramic material such as alumina, elements of the piezoelectric filter or the SAW filter are mounted on the package by die bonding, a terminal in the package is connected to electrodes of the elements by wire bonding, and then the package is sealed by a lid. Alternatively, in the above-described piezoelectric filter and SAW filter, an electrode land is formed on the bottom surface of the package comprising alumina, elements of the piezoelectric filter or the SAW filter are mounted on the package by flip-chip bonding, and then the package is sealed by a lid for realizing miniaturization.

[0006] In the above-described configuration, however, even though the elements in the piezoelectric filter or the SAW filter are miniaturized, miniaturization and lower profile of the piezoelectric filter and SAW filter cannot be realized as long as the package is not miniaturized. Also, the cost for compact package is high. Particularly, in the piezoelectric filter, the vibrating portion is formed on the opening or recessed portion of the substrate, and thus the vibrating portion may be broken due to impact caused by dicing of elements, and pick up or die bonding of elements at packaging.

[0007] On the other hand, bumps are used for packaging in Patent Documents 1 to 3. According to these Patent Documents, flip-chip mounting, in which a SAW element is bonded to a base substrate by using bumps on the base substrate, is adopted. In this method, space for wire bonding is not necessary, which results in miniaturization of a SAW filter. However, conductive pads corresponding to the bumps must be formed in the SAW element, which reduces an effective area of the SAW element. As a result, miniaturization of the SAW filter becomes difficult and cost for forming the bumps is required.

[0008] In Patent Document 4, a SAW element is mounted on a base substrate provided with a through hole facing a lead electrode of the SAW element and a conductive agent is filled in the through hole, so as to form an external circuit connecting portion. In this way, the SAW filter is miniaturized.

[Patent Document 1]

[0009] Japanese Unexamined Patent Application Publication No. 2001-94390

[Patent Document 2]

[0010] Japanese Unexamined Patent Application Publication No. 11-150441

[Patent Document 3]

[0011] Japanese Unexamined Patent Application Publication No. 2001-60642

[Patent Document 4]

[0012] Japanese Unexamined Patent Application Publication No. 2001-244785

Disclosure of Invention

[0013] In the configuration described in Patent Document 4, however, since the SAW filter is formed by bond-

ing the base substrate to the SAW element, the thickness of the SAW filter increases due to the base substrate.

[0014] The present invention has been made in view of the above-described problems in the known arts, and it is an object of the present invention to provide a compact piezoelectric component and a method for manufacturing the same.

[0015] In order to solve the above-described problems, a piezoelectric component of the present invention includes a piezoelectric element including at least one vibrating portion and an element wiring connected to the vibrating portion, which are formed on a substrate; and an external terminal. The piezoelectric component also includes an insulating layer including an opening serving as space for protecting the vibrating portion and a conductive opening. The external terminal is connected to the element wiring through an external terminal connecting member formed in the conductive opening.

[0016] With this configuration, the vibrating portion is protected by the opening serving as space for protecting the vibrating portion in the insulating layer. Therefore, degradation in the characteristic of the piezoelectric component due to packaging can be prevented. Also, the piezoelectric component does not require an element causing an increase in the thickness of the piezoelectric component, such as a substrate bonded for protecting the vibrating portion, and thus miniaturization, lower profile, and lower cost of the piezoelectric component can be realized. Further, since the position of the external terminal connected to the conductive opening can be arbitrarily changed on the insulating layer in accordance with an externally connected circuit. That is, the positioning freedom of the external terminal can be increased.

[0017] Preferably, a protective film is formed in the opening. With this configuration, the vibrating portion can be protected more reliably.

[0018] Also, the opening is preferably covered by a lid. With this configuration, the vibrating portion can be protected more reliably.

[0019] Further, in order to solve the above-described problems, a piezoelectric component of the present invention includes a piezoelectric element including at least one vibrating portion and an element wiring connected to the vibrating portion, which are formed on a substrate; and an external terminal. The piezoelectric component further includes an insulating layer which includes an opening serving as space for protecting the vibrating portion and a conductive opening and which is provided with a wiring connected to the element wiring through the conductive opening; and a second insulating layer which protects the wiring and which includes a second opening positioned over the opening and a second conductive opening, the second insulating layer being provided on the insulating layer. The external terminal is connected to the wiring through an external terminal connecting member formed in the second conductive opening.

[0020] With this configuration, since the wiring is protected by the second insulating layer, short circuit or the like caused by contact with the wiring at packaging of a SAW device can be prevented.

[0021] Additionally, in the piezoelectric component of the present invention, the wiring preferably includes any of a capacitor or inductor. With this configuration, a capacitor or inductor need not be provided independently, and thus the piezoelectric component can be miniaturized.

[0022] Preferably, a protective film is formed in the second opening. With this configuration, the vibrating portion can be protected more reliably.

[0023] Also, the second opening is preferably covered by a lid. With this configuration, the vibrating portion can be protected more reliably.

[0024] The piezoelectric element may be a SAW element including a vibrating portion having an IDT formed on a substrate.

[0025] Alternatively, the piezoelectric element may be a piezoelectric thin-film element including a vibrating portion formed by sandwiching the upper and lower surfaces of a thin-film portion having at least a layer of piezoelectric thin-film formed on an opening or a recessed portion in a substrate by at least a pair of upper and lower electrodes facing each other.

[0026] Alternatively, the piezoelectric element may be a piezoelectric thin-film element including a vibrating portion formed by sandwiching the upper and lower surfaces of a thin-film portion having at least a layer of piezoelectric thin-film formed on a substrate by at least a pair of upper and lower electrodes facing each other, space being provided between the substrate and the lower electrode in the vibrating portion.

[0027] In order to solve the above-described problems, the present invention provides a method for manufacturing a piezoelectric component including a piezoelectric element including at least one vibrating portion and an element wiring connected to the vibrating portion, which are formed on a substrate; and an external terminal. The method includes a step of manufacturing the piezoelectric element by forming the at least one vibrating portion and the element wiring connected to the vibrating portion on the substrate; a step of forming an insulating layer including an opening serving as space for protecting the vibrating portion and a conductive opening; a step of forming a first wiring so as to be connected to the element wiring through the conductive opening; and a step of forming the external terminal so as to be connected to the first wiring.

[0028] The piezoelectric element may be a SAW element including a vibrating portion having an IDT formed on a substrate.

[0029] According to the above-described method, the vibrating portion can be protected by the opening serving as space for protecting the vibrating portion in the insulating layer. Therefore, degradation in the charac-

teristic of the piezoelectric component due to packaging can be prevented. Also, the piezoelectric component does not require an element causing an increase in the thickness of the piezoelectric component, such as a substrate bonded for protecting the vibrating portion, and thus miniaturization, lower profile, and lower cost of the piezoelectric component can be realized. Further, since the position of the external terminal connected to the conductive opening can be arbitrarily changed on the insulating layer in accordance with an externally connected circuit. That is, the positioning freedom of the external terminal can be increased.

[0030] Also, in order to solve the above-described problems, the present invention provides a method for manufacturing a piezoelectric component including a piezoelectric element including at least one vibrating portion and an element wiring connected to the vibrating portion, which are formed on a substrate; and an external terminal. The method includes a step of manufacturing the piezoelectric element by forming the at least one vibrating portion and the element wiring connected 'to the vibrating portion on the substrate; a step of forming a protective layer for protecting the vibrating portion in the piezoelectric element; a step of forming an insulating layer including an opening serving as space for protecting the vibrating portion and a conductive opening; a step of forming a first wiring so as to be connected to the element wiring through the conductive opening; and a step of forming the external terminal so as to be connected to the first wiring.

[0031] The piezoelectric element may be a SAW element including a vibrating portion having an IDT formed on a substrate.

[0032] Alternatively, the piezoelectric element may be a piezoelectric thin-film element including a vibrating portion formed by sandwiching the upper and lower surfaces of a thin-film portion having at least a layer of piezoelectric thin-film formed on an opening or a recessed portion in a substrate by at least a pair of upper and lower electrodes facing each other.

[0033] Alternatively, the piezoelectric element may be a piezoelectric thin-film element including a vibrating portion formed by sandwiching the upper and lower surfaces of a thin-film portion having at least a layer of piezoelectric thin-film formed on a substrate by at least a pair of upper and lower electrodes facing each other, space being provided between the substrate and the lower electrode in the vibrating portion.

[0034] According to the above-described method, the vibrating portion can be protected by the protective film. Also, the vibrating portion can be protected by the opening serving as space for protecting the vibrating portion in the insulating layer. Therefore, degradation in the characteristic of the piezoelectric filter due to packaging can be prevented. Also, the piezoelectric component does not require an element causing an increase in the thickness of the piezoelectric component, such as a substrate facing the vibrating portion for protecting the vibrating portion, and thus miniaturization, lower profile, and lower cost of the piezoelectric component can be realized. Further, since the position of the external terminal connected to the conductive opening can be arbitrarily changed on the insulating layer in accordance with an externally connected circuit. That is, the positioning freedom of the external terminal can be increased.

[0035] Further, in order to solve the above-described problems, the present invention provides a method for manufacturing a piezoelectric component including a piezoelectric element including at least one vibrating portion and an element wiring connected to the vibrating portion, which are formed on a substrate; and an external terminal. The method includes a step of manufacturing the piezoelectric element by forming the at least one vibrating portion and the element wiring connected to the vibrating portion on the substrate; a step of forming an insulating layer including an opening serving as space for protecting the vibrating portion and a conductive opening; a step of forming a first wiring so as to be connected to the element wiring through the conductive opening; a step of forming a second insulating layer including a second conductive opening on the insulating layer; a step of forming a second wiring so as to be connected to the first wiring through the second conductive opening; and a step of forming the external terminal so as to be connected to the first wiring through the second wiring.

[0036] Also, in order to solve the above-described problems, the present invention provides a method for manufacturing a piezoelectric component including a piezoelectric element including at least one vibrating portion and an element wiring connected to the vibrating portion, which are formed on a substrate; and an external terminal. The method includes a step of manufacturing the piezoelectric element by forming the at least one vibrating portion and the element wiring connected to the vibrating portion on the substrate; a step of forming a protective layer for protecting the vibrating portion in the piezoelectric element; a step of forming an insulating layer including an opening serving as space for protecting the vibrating portion and a conductive opening; a step of forming a first wiring so as to be connected to the element wiring through the conductive opening; a step of forming a second insulating layer including a second conductive opening on the insulating layer; a step of forming a second wiring so as to be connected to the first wiring through the second conductive opening; and a step of forming the external terminal so as to be connected to the first wiring through the second wiring.

[0037] According to the above-described method, the first wiring is protected by the second insulating layer, and thus short circuit or the like caused by contact with the first wiring at packaging of the piezoelectric component can be prevented.

[0038] Preferably, the method further includes a step

of polishing the piezoelectric substrate.

[0039] According to the above-described method, the piezoelectric substrate can be thinned by polishing it. Preferably, the polishing step is performed after the insulating layer or the like is formed so as to reinforce the piezoelectric substrate. By this polishing step, the profile of the SAW device can be further reduced.

[0040] In the piezoelectric component of the present invention, the vibrating portion in the piezoelectric element is protected by a protective layer or a protective space forming member. Accordingly, degradation in the characteristic of the piezoelectric component due to packaging can be prevented. Also, the piezoelectric component does not require an element causing an increase in the thickness of the piezoelectric component, such as a substrate facing the vibrating portion for protecting the vibrating portion, and thus miniaturization, lower profile, and lower cost of the piezoelectric component can be realized.

Brief Descrigtion of the Drawings

[0041]

Fig. 1 includes cross-sectional views showing a process of manufacturing a SAW device according to a first embodiment of the present invention.

Fig. 2 includes cross-sectional views showing a process of manufacturing a SAW device according to a second embodiment of the present invention.

Fig. 3 includes cross-sectional views showing the process of manufacturing the SAW device according to the second embodiment of the present invention.

Fig. 4 is a circuit diagram showing a SAW device according to a modification of the first embodiment of the present invention.

Fig. 5 is a plan view showing a SAW element of the SAW device according to the modification of the first embodiment of the present invention.

Fig. 6 is a plan view showing a state where an insulating layer is formed on the SAW element shown in Fig. 5.

Fig. 7 is a plan view showing a state where external terminals are formed on the insulating layer shown in Fig. 6.

Fig. 8 is a cross-sectional view showing the SAW device according to the modification of the first embodiment of the present invention.

Fig. 9 is a circuit diagram showing a SAW device according to another modification of the first embodiment of the present invention.

Fig. 10 is a plan view showing a SAW element of the SAW device according to the above-described another modification of the first embodiment of the present invention.

Fig. 11 is a plan view showing a state where an insulating layer is formed on the SAW element shown in Fig. 10.

Fig. 12 is a plan view showing a state where external terminals are formed on the insulating layer shown in Fig. 11.

Fig. 13 is a circuit diagram showing a SAW device according to a modification of the second embodiment of the present invention.

Fig. 14 is a plan view showing a SAW element of the SAW device according to the modification of the second embodiment of the present invention.

Fig. 15 is a plan view showing a state where an insulating layer is formed on the SAW element shown in Fig. 14.

Fig. 16 is a plan view showing a state where wirings are formed on the insulating layer shown in Fig. 15.

Fig. 17 is a plan view showing a state where a second insulating layer is formed on the insulating layer shown in Fig. 16 and external terminals are formed.

Fig. 18 is a cross-sectional view showing the SAW device according to the modification of the second embodiment of the present invention.

Fig. 19 is a circuit diagram showing a SAW device according to another modification of the second embodiment of the present invention.

Fig. 20 is a plan view showing a SAW element of the SAW device according to the above-described another modification of the second embodiment of the present invention.

Fig. 21 is a plan view showing a state where an insulating layer is formed on the SAW element shown in Fig. 20.

Fig. 22 is a plan view showing a state where wirings are formed on the insulating layer shown in Fig. 21.

Fig. 23 is a plan view showing a state where a second insulating layer is formed on the insulating layer shown in Fig. 22 and external terminals are formed.

Fig. 24 is a circuit diagram showing the SAW device according to the above-described another modification of the second embodiment of the present invention.

Best Mode for Carrying Out the Invention

First Embodiment

[0042] Hereinafter, an embodiment of the present invention will be described with reference to Figs. 1 and 4 to 12.

[0043] As shown in Fig. 1, a SAW filter according to this embodiment includes a SAW element (piezoelectric element) 16 including at least one IDT (vibrating portion) 2 and a conductive pad (element wiring) 3 connected to the IDT 2, which are disposed on a piezoelectric substrate 1 comprising $LiTaO_3$; and an external terminal 12 connected to the conductive pad 3. The external terminal 12 is connected to the conductive pad 3 through a wiring (external terminal connecting member, first wiring) 11 extending in a conductive opening 8 in an insu-

lating layer 7, which is laminated on the conductive pad 3 and which comprises resin. The conductive opening 8 corresponds to a part where the insulating layer is not disposed on the conductive pad 3. Also, an exciting portion protective opening 9, which serves as space for protecting a SAW-exciting portion including the IDT 2, is formed in the insulating layer 7. The exciting portion protective opening 9 corresponds to a part where the insulating layer is not provided for the SAW-exciting portion including the IDT 2 on the $LiTaO_3$ piezoelectric substrate 1, that is, a part where a protective film (protective layer) 5 is formed.

[0044] In the above-described configuration, the SAW-exciting portion including the IDT 2 is protected by the protective film 5. Further, the IDT 2 is protected by the exciting portion protective opening 9 in the insulating layer 7. With this configuration, degradation in the characteristic of the SAW filter due to packaging can be prevented. Also, the above-described SAW filter does not require an element causing an increase in the thickness of the SAW filter, such as a substrate bonded for protecting the SAW-exciting portion including the IDT 2, and thus miniaturization, lower profile, and lower cost of the SAW filter can be realized. That is, packaging can be achieved in the size of the SAW element 16 or a chip.

[0045] Further, since the wiring 11 extending in the conductive opening 8 can be arbitrarily formed, the position of the external terminal 12 connected to the wiring 11 can be arbitrarily changed in accordance with an externally connected circuit. That is, the positioning freedom of the external terminal 12 can be increased.

[0046] The IDT 2 and the conductive pad 3 comprise Al, for example, and a layer comprising Ti, Ni, or Au may be laminated as necessary. Preferably, corrosion can be suppressed by using Au for the top layer.

[0047] As material for the protective film 5, SiN or SiO_2 may be used.

[0048] Even if the protective film 5 is not provided, reliability can be ensured to some extent.

[0049] The insulating layer 7 comprises an ordinary photoresist comprising photosensitive polyimide or a novolac resin, or an insulating material such as photosensitive benzocyclobuten. Alternatively, benzocyclobuten, a cyclic olefin resin, or an epoxy resin can be preferably used.

[0050] A protective metallic film 6 may be disposed on the surface opposite to the surface provided with the IDT 2 of the $LiTaO_3$ piezoelectric substrate 1. Accordingly, effects of externally coming electromagnetic waves on the SAW filter can be prevented by this protective metallic film 6. The protective metallic film 6 may comprise a material for blocking electromagnetic waves, such as Ti, Al, or NiCr.

[0051] Also, a buffer layer 10 may be disposed on the protective metallic film 6. When the protective metallic film is not provided, the buffer layer 10 may be directly provided on the $LiTaO_3$ piezoelectric substrate 1. The buffer layer 10 alleviates impact caused at packaging of the SAW filter. The buffer layer 10 may comprise a conductive or non-conductive resin. However, a conductive resin is preferably used, for example, an epoxy resin containing Ag particles. In this way, by applying conductivity, effects of externally applied electromagnetic waves can be prevented. In addition, pyroelectric destruction of the IDT on the pyroelectric $LiTaO_3$ substrate can be prevented.

[0052] In the SAW filter, a reinforcing substrate such as an alumina substrate may be disposed on the surface opposite to the surface provided with the IDT 2 of the $LiTaO_3$ piezoelectric substrate 1. This reinforcing substrate may be bonded to the surface opposite to the surface provided with the IDT 2 of the $LiTaO_3$ piezoelectric substrate 1 by using an adhesive or the like. The reinforcing substrate contributes to enhance the strength of the SAW filter.

[0053] Next, a method for manufacturing the SAW filter will be described with reference to Fig. 1.

[0054] First, in step 1, the IDT 2, the conductive pad 3, a reflector (not shown), a wiring (element wiring) (not shown), and so on are formed on the 100 mmϕ (i.e. 100 mmϕ diameter) $LiTaO_3$ substrate (piezoelectric substrate) 1 having a thickness of 0.35 mm. That is, the IDT 2, the conductive pad 3, the reflector, the wiring, and so on are formed on the $LiTaO_3$ piezoelectric substrate 1 by a lift-off method such as evaporation by using Al or the like. Further, an alignment mark 4 for positioning may be formed. Although the shape and size of the alignment mark 4 are not specified, it is circular-shaped and has a size of 10 μmϕ (i.e. 10 μmϕ diameter) in this case. Further, the protective film 5 comprising SiN or SiO_2 is formed at the part provided with the IDT 2 and the reflector, that is, at the SAW-exciting portion including the IDT 2, by spattering or the like in a thickness of 5 nm. The protective metallic film 6 comprising Ti or the like is formed on the surface opposite to the surface provided with the IDT 2 of the $LiTaO_3$ piezoelectric substrate 1. The protective metallic film 6 may be arbitrarily formed as necessary.

[0055] Then, in step 2, the insulating layer 7 having the conductive opening 8 and the exciting portion protective opening 9 is formed on the surface provided with the IDT 2 of the $LiTaO_3$ piezoelectric substrate 1. The insulating layer 7 can be formed by, for example, applying photosensitive polyimide in a thickness of 15 μm, and then performing exposure and development in accordance with a predetermined pattern so as to form the conductive opening 8 and the exciting portion protective opening 9.

[0056] Then, in step 3, the wiring 11 and the external terminal 12 are formed. The wiring 11 and the external terminal 12 can be formed by, for example, forming a resist pattern to be lifted off, forming a metallic film by laminating Au (200 nm), Pd (100 nm), and Ti (100 nm) in this order by evaporation, and then lifting off the resist. Alternatively, the wiring 11 and the external terminal 12 may be formed by filling a conductive paste in the con-

ductive opening 8 or printing it with a sufficient thickness, and then firing the conductive paste. As the conductive paste, a resin Ag paste, a solder paste, an Sn paste which can be sintered at a low temperature, or a Zn paste may be used. Also, the wiring 11 and the external terminal 12 may be formed by forming a metallic film and etching the film. In the above-described forming methods, the wiring 11 and the external terminal 12 can be formed at the same time, and thus a manufacturing process can be simplified. Alternatively, the wiring 11 and the external terminal 12 may be formed by filling a conductive paste in the conductive opening 8 and sintering it, and then performing evaporation or printing of the conductive paste so as to be connected to the sintered conductive paste.

[0057] Then, in step 4, the buffer layer 10 is formed on the protective metallic film 6 so as to alleviate impact of packaging. The buffer layer 10 may not be formed. When the buffer layer 10 is formed by using a conductive resin, the protective metallic film 6 is not necessary. Further, in this step, the strength of the SAW filter may be enhanced by bonding a reinforcing substrate. Finally, the produced substrate is diced at predetermined positions so that a SAW filter 21 can be obtained. Although only one SAW element 16 is shown in Fig. 1, a plurality of SAW elements may be formed.

[0058] According to the above-described method, the SAW-exciting portion including the IDT 2 can be protected by the protective film 5. Further, the IDT 2 can be protected by space defined by the exciting portion protective opening 9 in the insulating layer 7. Therefore, degradation in the characteristic of the SAW filter due to packaging can be prevented. Also, in the above-described SAW fitter, an element which causes an increase in the thickness of the SAW filter, such as a substrate facing the IDT 2 for protecting the SAW-exciting portion including the IDT 2, is not required. Accordingly, miniaturization, lower profile, and lower cost of the SAW filter can be realized. Further, steps of bonding substrates facing each other and etching of the substrates can be reduced, and thus the SAW filter can be easily manufactured while saving time.

[0059] Preferably, the conductive opening 8 is substantially tapered by setting appropriate exposure conditions. Accordingly, the wiring 11 at the conductive opening 8 can be formed more easily and also the SAW filter can be formed more easily.

[0060] If the protective metallic film 6 is not formed, the $LiTaO_3$ piezoelectric substrate 1 may be polished so as to reduce its thickness in step 2 or thereafter. This polishing step can be performed because the $LiTaO_3$ piezoelectric substrate 1 is reinforced by forming the insulating layer 7 and so on. In this way, a lower-profile SAW filter can be obtained.

[0061] Preferably, a negative resist is used for each resist pattern. By using a negative resist, remaining of resist at the opening can be prevented.

[0062] In the insulating layer 7, a dicing opening may be formed at a dicing portion of the SAW filter. By using this dicing opening, positioning for dicing can be easily performed, and clogging at dicing can be prevented. Preferably, the width of the dicing opening is equal to the width of a dicing blade used for dicing. Accordingly, a protruded portion of a product after dicing can be prevented from being damaged.

[0063] Next, a SAW filter according to a modification of this embodiment will be described with reference to Figs. 4 to 8.

[0064] Fig. 4 is a circuit diagram showing a SAW filter 100 of this modification. The SAW filter 100 includes SAW resonators 101 to 105 arranged in a ladder pattern, each resonator having an IDT (vibrating portion). The SAW resonators 101 to 103 are series resonators and the SAW resonators 104 and 105 are parallel resonators.

[0065] Hereinafter, the SAW filter 100 will be described with reference to Figs. 5 to 8.

[0066] As shown in Fig. 5, the SAW resonators 101 to 105, conductive pads (element wirings) 106 to 109, and wirings (element wirings) 110 to 115 are formed on the piezoelectric substrate 1 so as to form a SAW element 116. Also, a protective film (not shown) for protecting the SAW resonators 101 to 105 is formed.

[0067] Then, as shown in Fig. 6, an insulating layer 124 is formed on the SAW element 116. The insulating layer 124 includes exciting portion protective openings 117 to 119 for exposing the SAW resonators 101 to 105 and conductive openings 120 to 123 for exposing the conductive pads 106 to 109. Alternatively, the insulating layer 124 may cover the entire surface of the piezoelectric substrate 1.

[0068] Then, as shown in Fig. 7, external terminal connecting members (first wirings) 125 to 128 connected to the conductive pads 106 to 109 through the conductive openings 120 to 123 and externals terminals 129 to 132 connected to the external terminal connecting members 125 to 128 are formed on the insulating layer 124, so as to obtain the SAW filter 100.

[0069] Fig. 8 is a cross-sectional view of the produced SAW filter 100, taken along the line A-A' in Figs. 5 to 7.

[0070] As shown in Fig. 8, in the SAW filter 100, the exciting portions including the IDTs of the SAW resonators are protected by the exciting portion protective openings 117 and 119. Also, the IDTs of the SAW resonators are protected by protective films 133 and 134. Further, the exciting portion protective openings 117 and 119 may be covered by a lid so as to prevent conductive particles from contacting the IDTs. Accordingly, degradation in the characteristic of the SAW filter can be prevented.

[0071] Next, a SAW filter according to another modification of this embodiment will be described with reference to Figs. 9 to 12.

[0072] Fig. 9 is a circuit diagram showing a SAW filter 200 of this modification. The SAW filter 200 includes SAW resonators 201 to 205 arranged in a ladder pattern,

each resonator having an IDT (vibrating portion). The SAW resonators 201 to 203 are series resonators and the SAW resonators 204 and 205 are parallel resonators.

[0073] Hereinafter, a method for manufacturing the SAW filter 200 will be described with reference to Figs. 10 to 12.

[0074] First, as shown in Fig. 10, the SAW resonators 201 to 205 and wirings (element wirings) 206 to 211 are formed on the piezoelectric substrate 1 so as to form a SAW element 212.

[0075] Then, as shown in Fig. 11, an insulating layer 220 is formed on the SAW element 212. The insulating layer 220 includes exciting portion protective openings 213 to 215 for exposing the SAW resonators 201 to 205 and conductive openings 216 to 219 for exposing end portions of the wirings 206 to 211.

[0076] Then, as shown in Fig. 12, external terminal connecting members (first wirings) 221 to 224 connected to the wirings 206, 209, 210, and 211 through the conductive openings 216 to 219 and external terminals 225 to 228 connected to the external terminal connecting members 221 to 224 are formed on the insulating layer 220. Further, protective films are formed on the exciting portion protective openings 213 to 215 so as to obtain the SAW filter 200.

[0077] In each of the above-described SAW filters, an element wiring is connected to each IDT on the piezoelectric substrate, but part of the element wirings can be omitted. In that case, the conductive openings are formed in the insulating layer such that a busbar of each IDT is exposed. Accordingly, space for wirings and conductive pads on the piezoelectric substrate can be saved, and thus the SAW filter can be miniaturized.

Second Embodiment

[0078] Hereinafter, another embodiment of the present invention will be described with reference to Figs. 2 and 3 and 13 to 24. For convenience in describing, members having the same function as that in the first embodiment are denoted by the same reference numerals, and the corresponding description will be omitted.

[0079] As shown in Figs. 2 and 3, a SAW filter according to this embodiment is different from that of the first embodiment in that a wiring protective layer (second insulating layer) 13 for protecting the wiring 11 to be connected to the external terminal 12 is provided. The external terminal 12 is connected to the wiring 11 through a conductive opening (second conductive opening) 14 in the wiring protective layer 13.

[0080] Hereinafter, a method for manufacturing the SAW filter will be described with reference to Figs. 2 and 3.

[0081] In this embodiment, steps 1 and 2 are the same as in the first embodiment.

[0082] In step 3, only the wiring 11 is formed in this embodiment, whereas the wiring 11 and the external terminal 12 are formed in the first embodiment.

[0083] In step 4, the wiring protective layer 13 including the conductive opening 14 and a second opening is formed. In the wiring protective layer 13, the part of the exciting portion protective opening 9 serves as the second opening (second exciting portion protective opening). The wiring protective layer 13 can be formed in the same way as that for the insulating layer 7. For example, the wiring protective layer 13 can be formed by applying photosensitive polyimide and then performing exposure and development in accordance with a predetermined pattern so as to include the conductive opening 14 and the second opening at the exciting portion protective opening 9.

[0084] Then, in step 5, the external terminal 12 is formed in the conductive opening 14. The external terminal 12 may be formed in the same way as in the first embodiment.

[0085] Then, in step 6, the buffer layer 10 and so on are formed as in step 4 of the first embodiment, and the produced substrate is diced at predetermined positions, so that a SAW filter 22 can be obtained.

[0086] As described above, the wiring protective layer 13 is formed on the wiring 11 in this method. Accordingly, short circuit or the like caused by contact of the external terminal 12 and the wiring 11 at packaging of the SAW filter can be prevented.

[0087] In this embodiment, the part provided with the exciting portion protective opening 9 in the wiring protective layer 13 serves as the second opening. However, the second opening may not be provided. When the second opening is not provided, the space defined by the exciting portion protective opening 9 in the insulating layer 7 is hollow, so that the space is provided over the SAW-exciting portion including the IDT 2. Accordingly, degradation in the characteristic of the SAW filter due to packaging can be prevented. Also, the exciting portion protective opening 9 may be covered by a lid.

[0088] The part of the external terminal 12 formed in the conductive opening 14 can be regarded as an external terminal connecting member (second wiring). That is, the external terminal 12 includes an external terminal connecting member and an external terminal. Alternatively, the external terminal connecting member and the external terminal may be separated and each of them may be formed in a different method.

[0089] Next, a SAW filter according to a modification of this embodiment will be described with reference to Figs. 13 to 18.

[0090] Fig. 13 is a circuit diagram showing a SAW filter 300 of this modification. The SAW filter 300 includes SAW resonators 301 to 305 arranged in a ladder pattern, each resonator including an IDT (vibrating portion). The SAW resonators 301 to 303 are series resonators and the SAW resonators 304 and 305 are parallel resonators. Inductors 306 and 307 are connected to the SAW resonators 304 and 305 in series, respectively.

[0091] Hereinafter, the SAW filter 300 will be described with reference to Figs. 14 to 17.

[0092] First, as shown in Fig. 14, the SAW resonators 301 to 305, conductive pads (element wirings) 308 to 311, and wirings (element wirings) 312 to 317 are formed on the piezoelectric substrate 1 so as to form a SAW element 318.

[0093] Then, as shown in Fig. 15, an insulating layer 322 is formed on the SAW element 318. The insulating layer 322 includes exciting portion protective openings 318 to 320 for exposing the SAW resonators 301 to 305 and conductive openings 318 to 321 for exposing the conductive pads 308 to 311. The insulating layer 322 may cover the entire surface of the piezoelectric substrate 1.

[0094] Then, as shown in Fig. 16, wirings (first wirings) 323 to 326 connected to the conductive pads 308 to 311 through the conductive openings 318 to 321 are formed on the insulating layer 322. In this configuration, each of the wirings 325 and 326 has an inductor L. Alternatively, each wiring may have a capacitor C. The inductors L in the wirings 325 and 326 correspond to the inductors 306 and 307.

[0095] Further, as shown in Fig. 17, a second insulating layer 334 is formed on the insulating layer 322. The second insulating layer 334 includes second exciting portion protective openings 327 to 329 for exposing the SAW resonators 301 to 305 through the exciting portion protective openings 318 to 320 and second conductive openings 330 to 333 for exposing end portions of the wirings 323 to 326. Then, external terminals 335 to 338 connected to the wirings 323 to 326 through the second conductive openings 330 to 333 are formed on the second insulating layer 334, so that the SAW filter 300 can be obtained. The parts of the external terminals 335 to 338 formed in the second conductive openings 330 to 333 may be regarded as external terminal connecting members (second wirings). That is, each of the external terminals 335 to 338 includes an external terminal connecting member and an external terminal. The external terminal connecting member and the external terminal may be separated and each of them may be formed in a different method.

[0096] Fig. 18 is a cross-sectional view of the produced SAW filter 300, taken along the line A-A' in Figs. 15 to 17.

[0097] As shown in Fig. 18, in the SAW filter 300, vibrating space for the SAW resonators 304 and 305 can be obtained by providing the exciting portion protective openings 318 and 320 and the second exciting portion protective openings 327 and 329.

[0098] Alternatively, a protective film may be formed on the IDT of each SAW resonator so as to protect the IDT. Further, the IDT can be protected by covering each second exciting portion protective opening by a lid.

[0099] Also, instead of forming the conductive pads 308 to 311, the wirings 312, 315, 316, and 317 may be connected to the wirings 323 to 326, respectively.

[0100] Hereinafter, a SAW filter according to another modification of this embodiment will be described with reference to Figs. 19 to 24.

[0101] Fig. 19 is a circuit diagram showing a SAW filter 400 of this modification. The SAW filter 400 includes SAW resonators 401 to 405 arranged in a ladder pattern, each resonator including an IDT (vibrating portion). The SAW resonators 401 to 403 are series resonators and the SAW resonators 404 and 405 are parallel resonators. Inductors 406 and 407 are connected to the SAW resonators 404 and 405 in series, respectively.

[0102] Hereinafter, the SAW filter 400 will be described with reference to Figs. 20 to 24.

[0103] First, as shown in Fig. 20, the SAW resonators 401 to 405 and wirings (element wirings) 408 to 415 are formed on the piezoelectric substrate 1 so as to form a SAW element 416.

[0104] Then, as shown in Fig. 21, an insulating layer 428 is formed on the SAW element 416. The insulating layer 428 includes exciting portion protective openings 417 to 419 for exposing the SAW resonators 401 to 405 and conductive openings 420 to 427 for exposing the wirings 408 to 415. The insulating layer 428 may cover the entire surface of the piezoelectric substrate 1.

[0105] Then, as shown in Fig. 22, wirings (first wirings) 429 to 432 connected to the wirings 408, 411, 412, and 415 through the conductive openings 420, 423, 424, and 427 are formed on the insulating layer 428. Also, a connecting wiring (first wiring) 433 for connecting the wirings 409 and 413 and a connecting wiring (first wiring) 434 for connecting the wirings 410 and 414 are formed. In this configuration, each of the wirings 431 and 432 has an inductor L, but each wiring may have a capacitor C. The inductors L in the wirings 431 and 432 correspond to the inductors 406 and 407.

[0106] Further, as shown in Fig. 23, a second insulating layer 442 is formed on the insulating layer 428. The second insulating layer 442 includes second exciting portion protective openings 435 to 437 for exposing the SAW resonators 401 to 405 through the exciting portion protective openings 417 to 419 and second conductive openings 438 to 441 for exposing end portions of the wirings 429 to 432. Then, external terminals 443 to 446 connected to the wirings 429 to 432 through the second conductive openings 438 to 441 are formed on the second insulating layer 442. The parts of the external terminals 443 to 446 formed in the second conductive openings 438 to 441 may be regarded as external terminal connecting members (second wirings). That is, each of the external terminals 443 to 446 includes an external terminal connecting member and an external terminal. The external terminal connecting member and the external terminal may be separated and each of them may be formed in a different way.

[0107] Then, a lid for covering the second exciting portion protective openings 435 to 437 is formed by thermo-compression bonding or the like. Accordingly, the SAW filter 400 can be obtained. Preferably, a platy lid

comprising photosensitive polyimide, polyethylenenaphtalate, liquid crystal polymer, glass, silicon, or alumina may be used. By using the lid, the IDTs of the SAW resonators can be protected. Further, short circuit caused by contact between conductive particles and the IDTs can be prevented. That is, degradation in the characteristic of the SAW filter can be prevented.

[0108] Fig. 24 is a cross-sectional view showing the produced SAW filter 400, taken along the line A-A' in Figs. 20 to 23.

[0109] As shown in Fig. 24, in the SAW filter 400, exciting space (vibrating space) for the IDTs can be obtained by the lid 447, so that the IDTs can be protected.

[0110] In the above-described SAW filters, an element wiring is connected to each IDT on the piezoelectric substrate 1, but the element wiring may be omitted. In that case, each conductive opening is formed in the insulating layer so that the busbar of each IDT is exposed therefrom. Accordingly, space for forming wirings and conductive pads on the piezoelectric substrate can be saved, and thus the SAW filter can be miniaturized.

[0111] In the second embodiment, a SAW filter is used as a piezoelectric filter. Alternatively, a piezoelectric thin-film filter may be used as a piezoelectric filter. In the piezoelectric thin-film filter, a piezoelectric thin-film element is used as a piezoelectric element. The piezoelectric thin-film element includes an Si substrate having an opening or a recessed portion; and at least one piezoelectric thin-film resonator (vibrating portion) formed by sandwiching the upper and lower surfaces of a thin-film portion having at least one layer of piezoelectric thin-film (comprising ZnO or AlN) formed on the opening or the recessed portion by at least one pair of upper and lower electrodes facing each other. Alternatively, the Si substrate may not include an opening or recessed portion, and space may be provided between the lower electrode and the Si substrate. In this piezoelectric thin-film filter, vibrating space for the piezoelectric thin-film resonator can be ensured by an exciting portion protective opening. Also, by sealing the exciting portion protective opening by a lid, the piezoelectric thin-film resonator can be protected. A protective film is not provided in the piezoelectric filter.

[0112] In the second embodiment, the second conductive opening is displaced from the position of the conductive opening. However, the positions of the conductive opening and the second conductive opening may correspond to each other. With this arrangement, conductive pads and part of the wirings become unnecessary, and thus the piezoelectric component can be miniaturized. Further, by removing the conductive pads and part of the wirings, parasitic capacitance can be reduced.

[0113] In the above-described embodiments, a piezoelectric substrate is used for a SAW element. When wirings are provided on the piezoelectric substrate, parasitic capacitance is generated at a part where wirings having different potentials face each other in a plane view due to high permittivity of the piezoelectric substrate, and thus insertion loss occurs. However, in the SAW filter of the present invention, the number of wirings provided on the piezoelectric substrate can be reduced, and necessary wirings can be formed on a resin layer or bonded substrate comprising a material having lower permittivity than that of the piezoelectric substrate. Accordingly, generation of parasitic capacitance can be suppressed at a part where wirings having different potentials face each other in a plane view.

[0114] The present invention is not limited to the above-described embodiments, and various modifications can be realized within the scope of the attached claims. Also, technical methods disclosed in the embodiments may be arbitrarily combined so as to obtain another embodiment, which is included in the scope of the present invention.

[0115] According to the present invention, piezoelectric components, such as SAW devices and piezoelectric thin-film filters, used for delay lines and filters can be miniaturized. Further, the piezoelectric components can be used for communication apparatuses such as portable phones, and the communication apparatuses can also be miniaturized.

Claims

1. A piezoelectric component comprising a piezoelectric element including at least one vibrating portion and an element wiring connected to the vibrating portion, which are formed on a substrate; and an external terminal, the piezoelectric component comprising:

   an insulating layer including an opening serving as space for protecting the vibrating portion and a conductive opening,

   wherein the external terminal is connected to the element wiring through an external terminal connecting member formed in the conductive opening.

2. A piezoelectric component according to Claim 1, wherein a protective film is formed in the opening.

3. A piezoelectric component according to Claim 1, wherein the opening is covered by a lid.

4. A piezoelectric component comprising a piezoelectric element including at least one vibrating portion and an element wiring connected to the vibrating portion, which are formed on a substrate; and an external terminal, the piezoelectric component comprising:

   an insulating layer which includes an opening

serving as space for protecting the vibrating portion and a conductive opening and which is provided with a wiring connected to the element wiring through the conductive opening; and
a second insulating layer which protects the wiring and which includes a second opening positioned over the opening and a second conductive opening, the second insulating layer being provided on the insulating layer,

wherein the external terminal is connected to the wiring through an external terminal connecting member formed in the second conductive opening.

5. A piezoelectric component according to Claim 4, wherein the wiring comprises any of a capacitor or inductor.

6. A piezoelectric component according to Claim 4, wherein a protective film is formed in the second opening.

7. A piezoelectric component according to Claim 4, wherein the second opening is covered by a lid.

8. A piezoelectric component according to Claim 1, wherein the piezoelectric element is a SAW element comprising a vibrating portion including an IDT formed on a substrate.

9. A piezoelectric component according to Claim 1, wherein the piezoelectric element is a piezoelectric thin-film element comprising a vibrating portion formed by sandwiching the upper and lower surfaces of a thin-film portion having at least a layer of piezoelectric thin-film formed on an opening or a recessed portion in a substrate by at least a pair of upper and lower electrodes facing each other.

10. A piezoelectric component according to Claim 1, wherein the piezoelectric element is a piezoelectric thin-film element comprising a vibrating portion formed by sandwiching the upper and lower surfaces of a thin-film portion having at least a layer of piezoelectric thin-film formed on a substrate by at least a pair of upper and lower electrodes facing each other, space being provided between the substrate and the lower electrode in the vibrating portion.

11. A method for manufacturing a piezoelectric component comprising a piezoelectric element including at least one vibrating portion and an element wiring connected to the vibrating portion, which are formed on a substrate; and an external terminal, the method comprising:

a step of manufacturing the piezoelectric element by forming said at least one vibrating portion and the element wiring connected to the vibrating portion on the substrate;
a step of forming an insulating layer including an opening serving as space for protecting the vibrating portion and a conductive opening;
a step of forming a first wiring so as to be connected to the element wiring through the conductive opening; and
a step of forming the external terminal so as to be connected to the first wiring.

12. A method for manufacturing a piezoelectric component comprising a piezoelectric element including at least one vibrating portion and an element wiring connected to the vibrating portion, which are formed on a substrate; and an external terminal, the method comprising:

a step of manufacturing the piezoelectric element by forming said at least one vibrating portion and the element wiring connected to the vibrating portion on the substrate;
a step of forming a protective layer for protecting the vibrating portion in the piezoelectric element;
a step of forming an insulating layer including an opening serving as space for protecting the vibrating portion and a conductive opening;
a step of forming a first wiring so as to be connected to the element wiring through the conductive opening; and
a step of forming the external terminal so as to be connected to the first wiring.

13. A method for manufacturing a piezoelectric component according to Claim 11, wherein the piezoelectric element is a SAW element comprising a vibrating portion including an IDT formed on a substrate.

14. A method for manufacturing a piezoelectric component according to Claim 12, wherein the piezoelectric element is a piezoelectric thin-film element comprising a vibrating portion formed by sandwiching the upper and lower surfaces of a thin-film portion having at least a layer of piezoelectric thin-film formed on an opening or a recessed portion in a substrate by at least a pair of upper and lower electrodes facing each other.

15. A method for manufacturing a piezoelectric component according to Claim 12, wherein the piezoelectric element is a piezoelectric thin-film element comprising a vibrating portion formed by sandwiching the upper and lower surfaces of a thin-film portion having at least a layer of piezoelectric thin-film formed on an opening or a recessed portion in a substrate by at least a pair of upper and lower elec-

trodes facing each other.

16. A method for manufacturing a piezoelectric component comprising a piezoelectric element including at least one vibrating portion and an element wiring connected to the vibrating portion, which are formed on a substrate; and an external terminal, the method comprising:

a step of manufacturing the piezoelectric element by forming said at least one vibrating portion and the element wiring connected to the vibrating portion on the substrate;
a step of forming an insulating layer including an opening serving as space for protecting the vibrating portion and a conductive opening;
a step of forming a first wiring so as to be connected to the element wiring through the conductive opening;
a step of forming a second insulating layer including a second conductive opening on the insulating layer;
a step of forming a second wiring so as to be connected to the first wiring through the second conductive opening; and
a step of forming the external terminal so as to be connected to the first wiring through the second wiring.

17. A method for manufacturing a piezoelectric component comprising a piezoelectric element including at least one vibrating portion and an element wiring connected to the vibrating portion, which are formed on a substrate; and an external terminal, the method comprising:

a step of manufacturing the piezoelectric element by forming said at least one vibrating portion and the element wiring connected to the vibrating portion on the substrate;
a step of forming a protective layer for protecting the vibrating portion in the piezoelectric element;
a step of forming an insulating layer including an opening serving as space for protecting the vibrating portion and a conductive opening;
a step of forming a first wiring so as to be connected to the element wiring through the conductive opening;
a step of forming a second insulating layer including a second conductive opening on the insulating layer;
a step of forming a second wiring so as to be connected to the first wiring through the second conductive opening; and
a step of forming the external terminal so as to be connected to the first wiring through the second wiring.

18. A method for manufacturing a piezoelectric component according to Claim 11, further comprising a step of polishing the substrate.

FIG. 1

STEP 1
2
16
6
1
3
5
3
4
STEP 2
3
2
3
4
16
6
1
7
8
5
9
8
STEP 3
3
2
3
4
16
6
1
7
12
11
8
5
9
8
11
12
STEP 4
21
3
2
3
4
16
10
6
1
7
12
11
8
5
9
8
11
12

FIG. 2

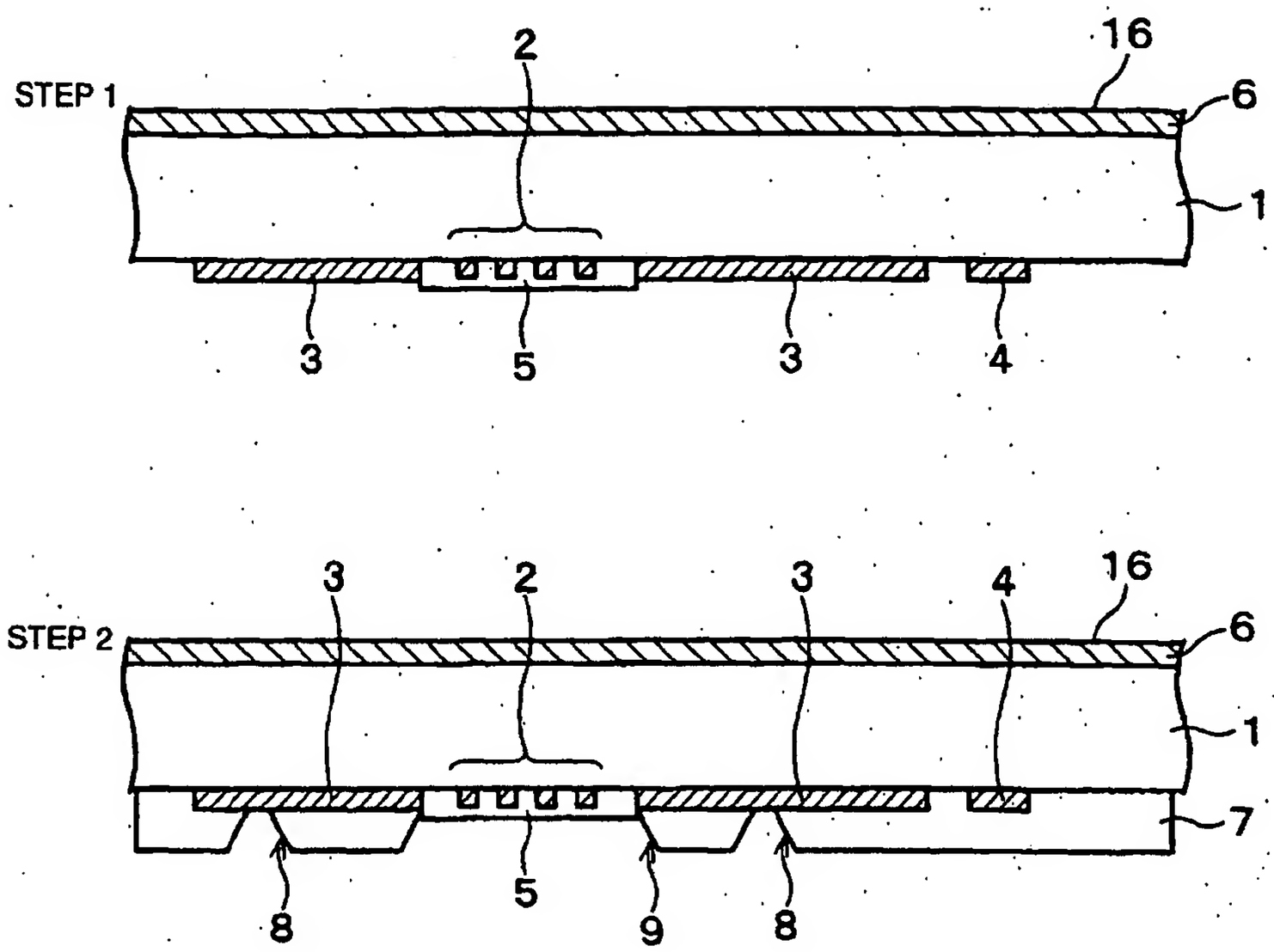

STEP 1
2
16
6
1
3
5
3
4
STEP 2
3
2
3
4
16
6
1
7
8
5
9
8
STEP 3
3
2
3
4
16
6
1
7
11
8
5
9
8
11

FIG. 3

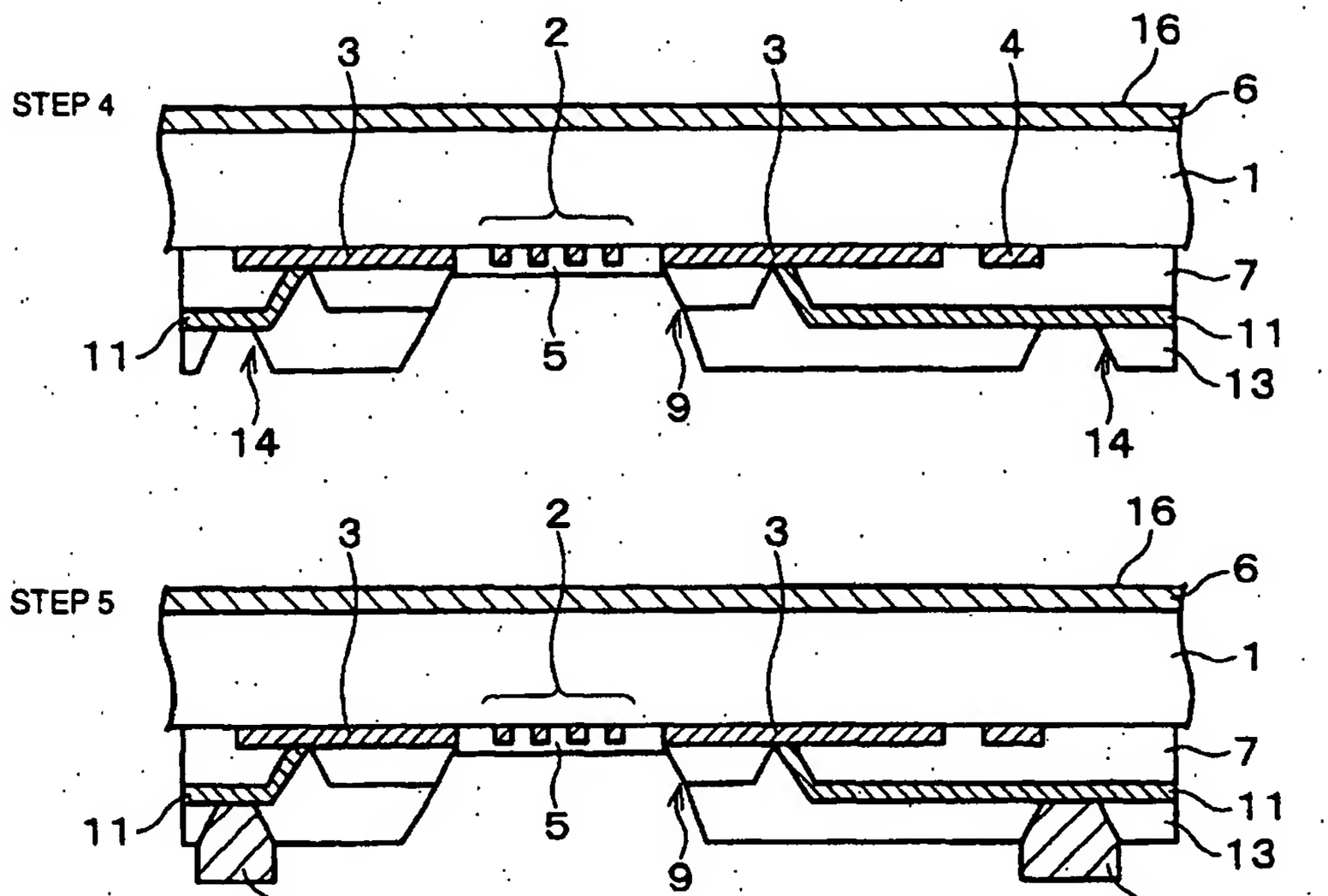

STEP 4
3
2
3
4
16
6
1
7
11
5
9
11
13
14
14
STEP 5
3
2
3
16
6
1
7
11
5
9
11
13
12
12
STEP 6
3
2
3
16
4
10
6
1
7
11
5
9
11
13
12
12
22

FIG. 4

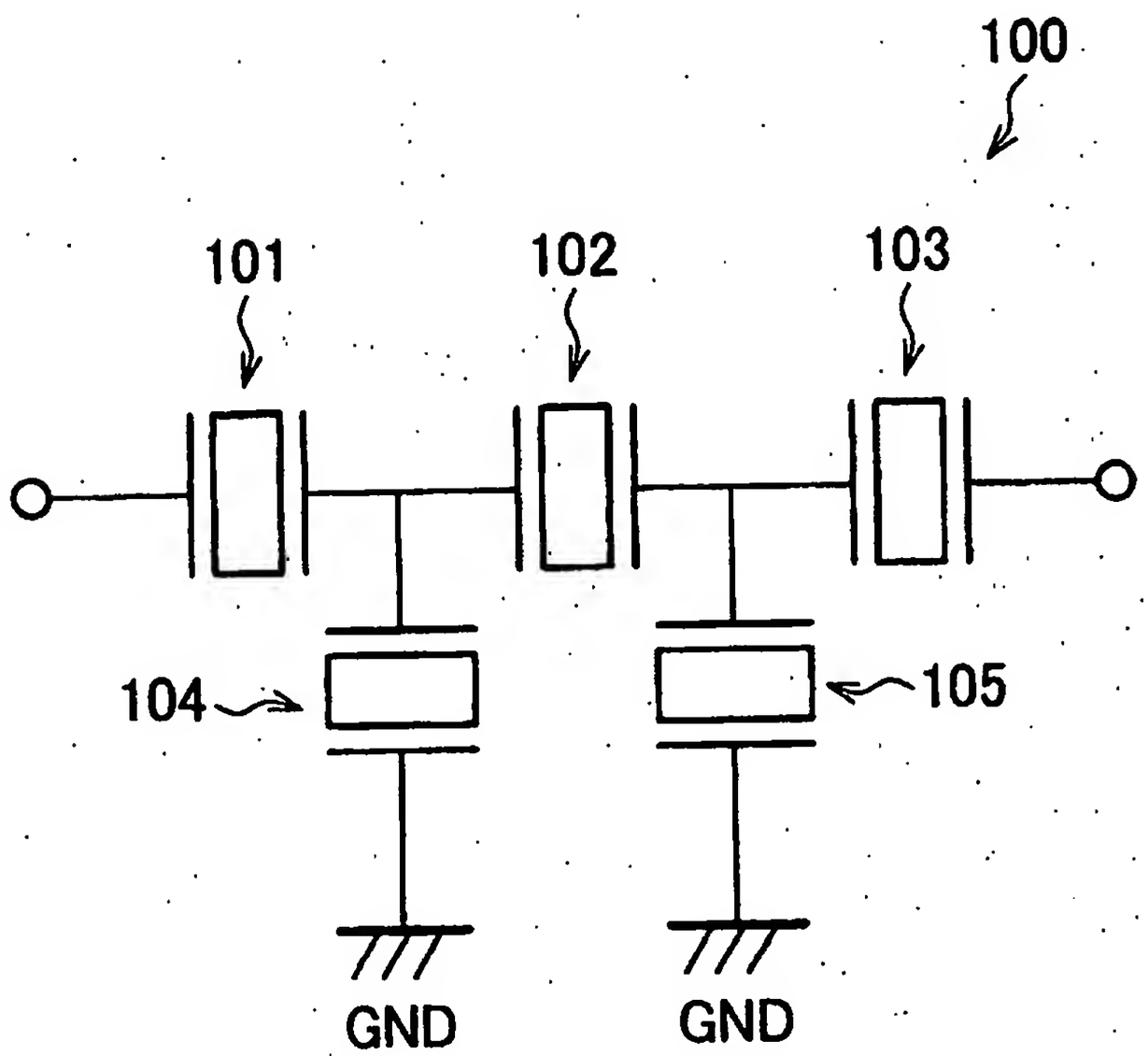


FIG. 5

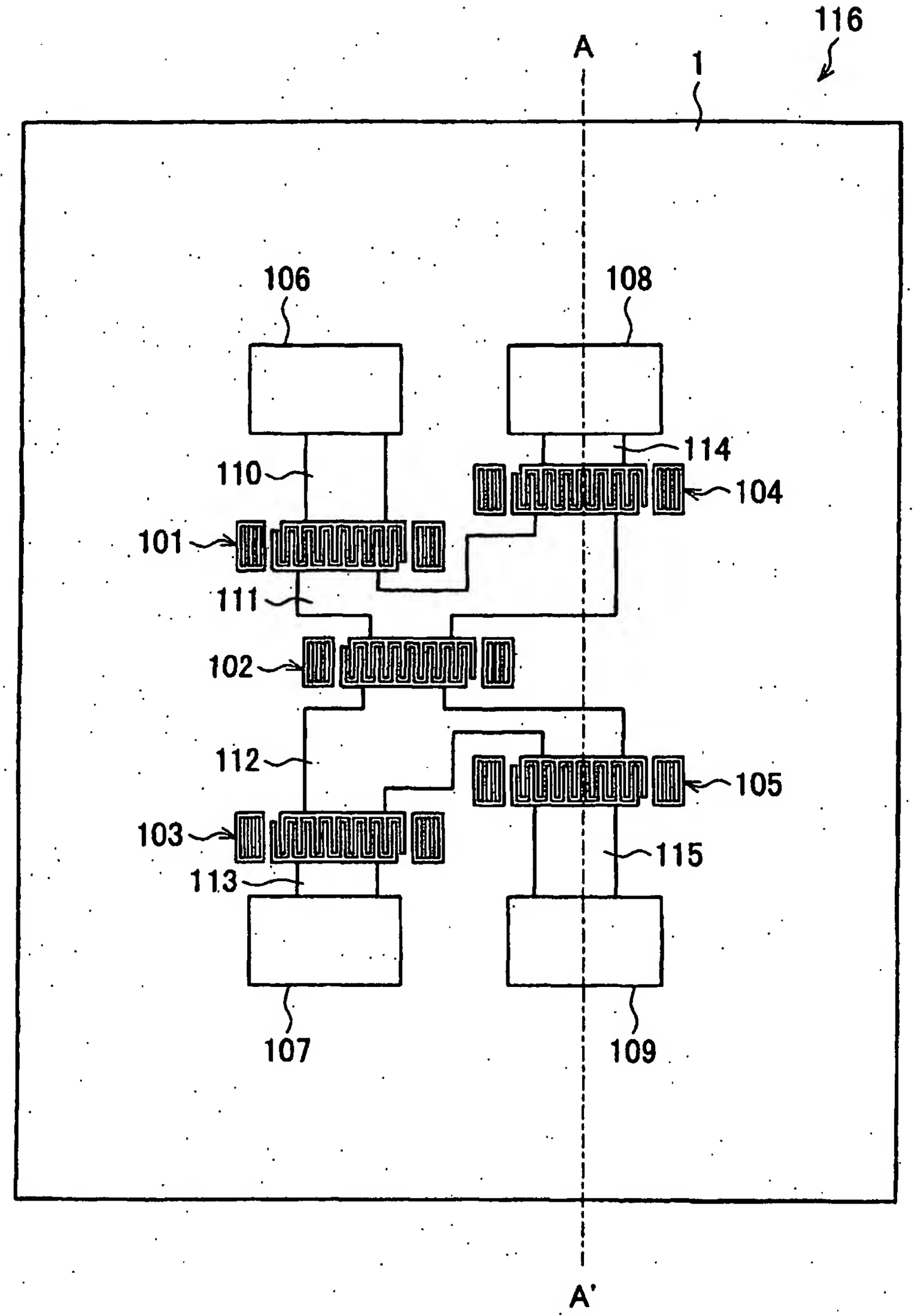

116
A
1
106
108
110
114
104
101
111
102
112
105
103
115
113
107
109
A'

FIG. 6

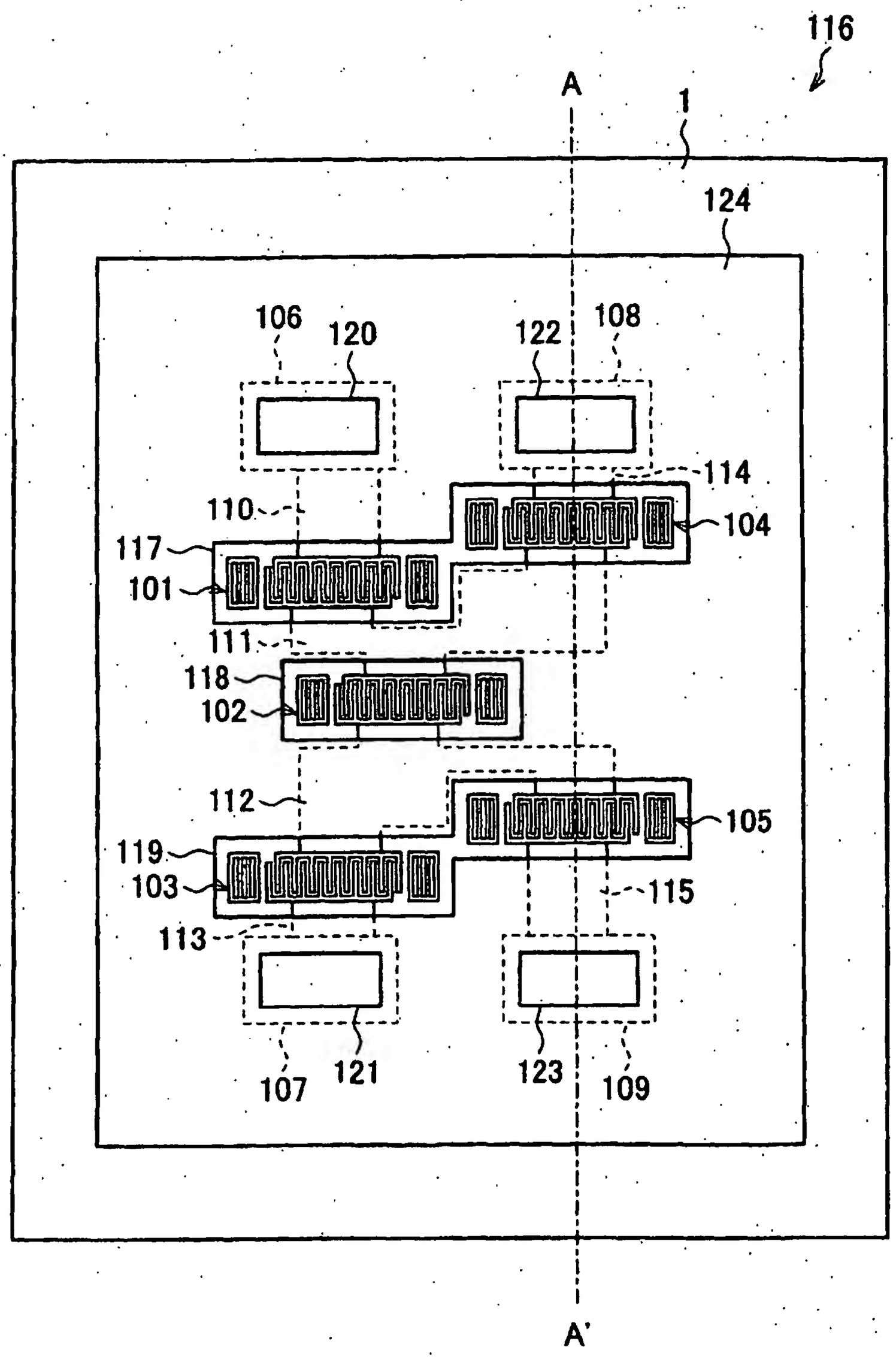

116
A
1
124
106
120
122
108
114
110
104
117
101
111
118
102
112
105
119
103
115
113
107
121
123
109
A'

FIG. 7

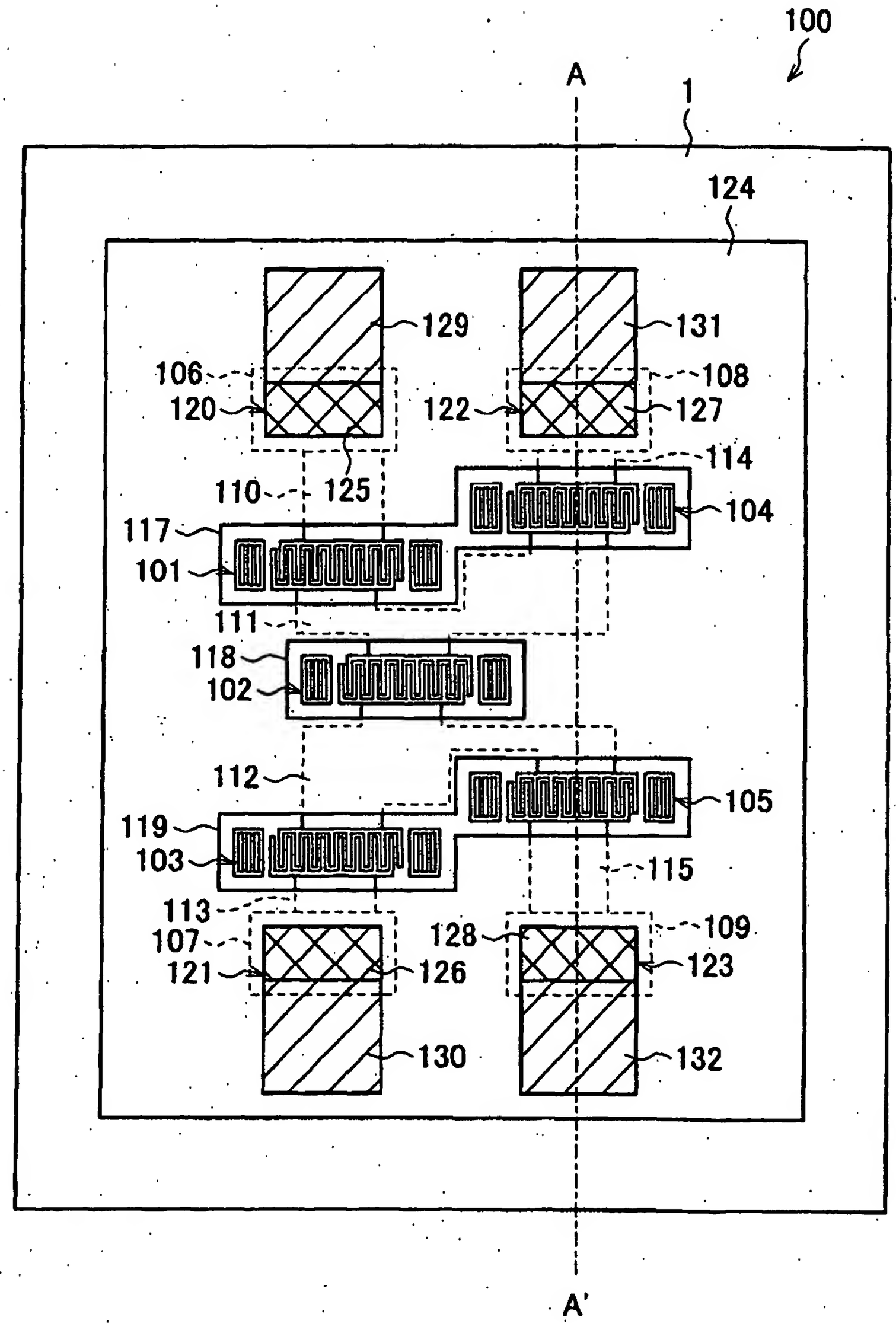

100
A
1
124
129
131
106
108
120
122
127
114
110
125
104
117
101
111
118
102
112
105
119
103
115
113
109
107
128
121
126
123
130
132
A'

FIG. 8

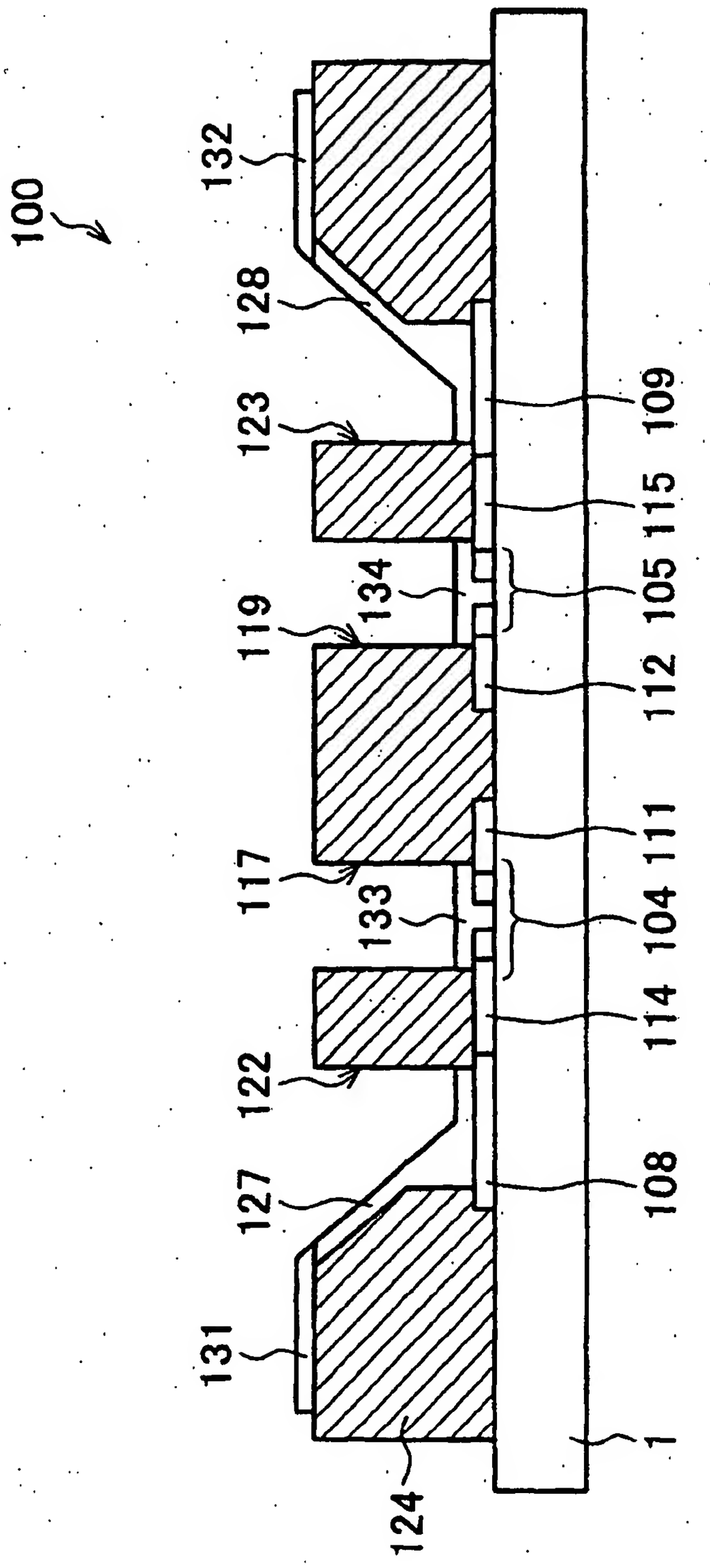

100
132
128
123
109
115
134
105
119
112
117
111
133
104
114
122
127
108
131
1
124

FIG. 9

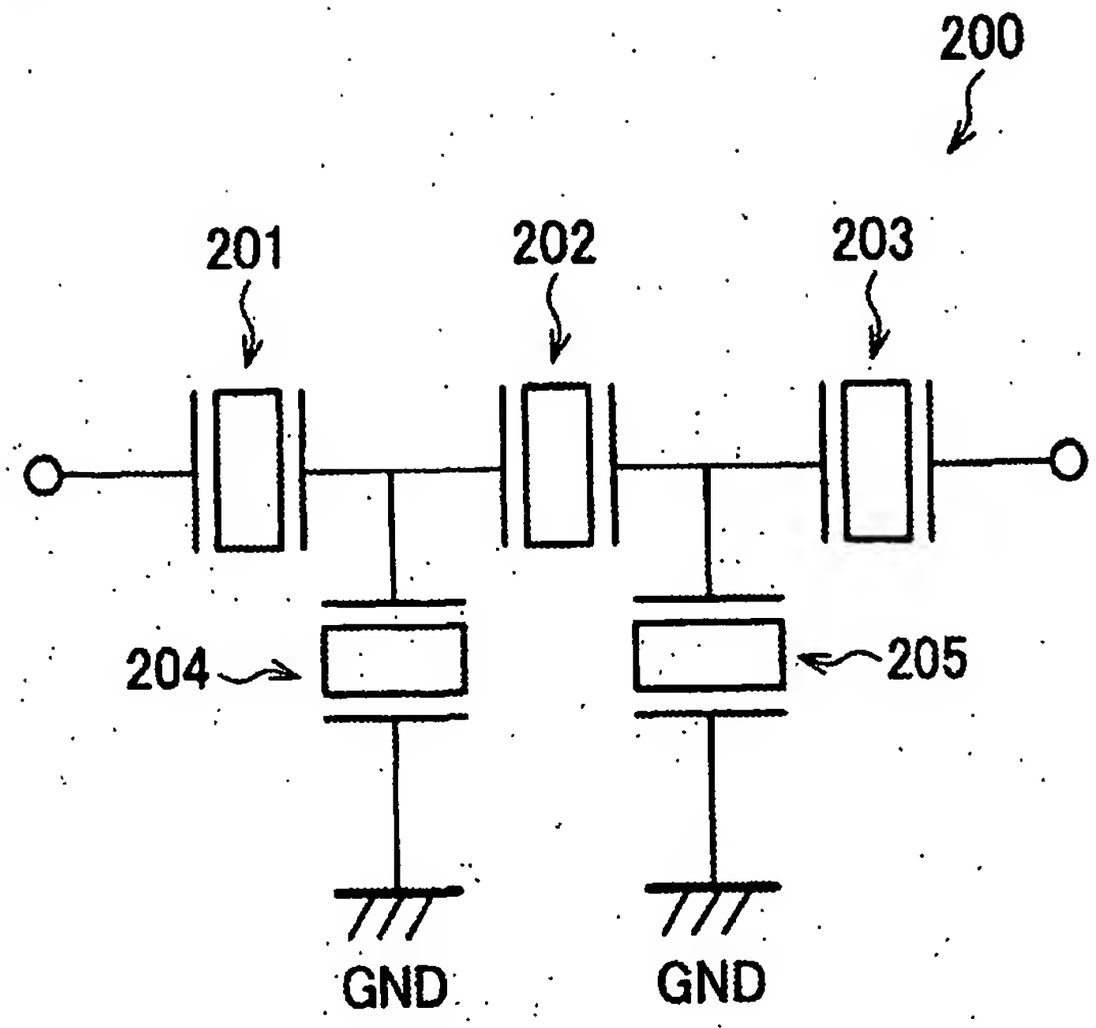


FIG. 10

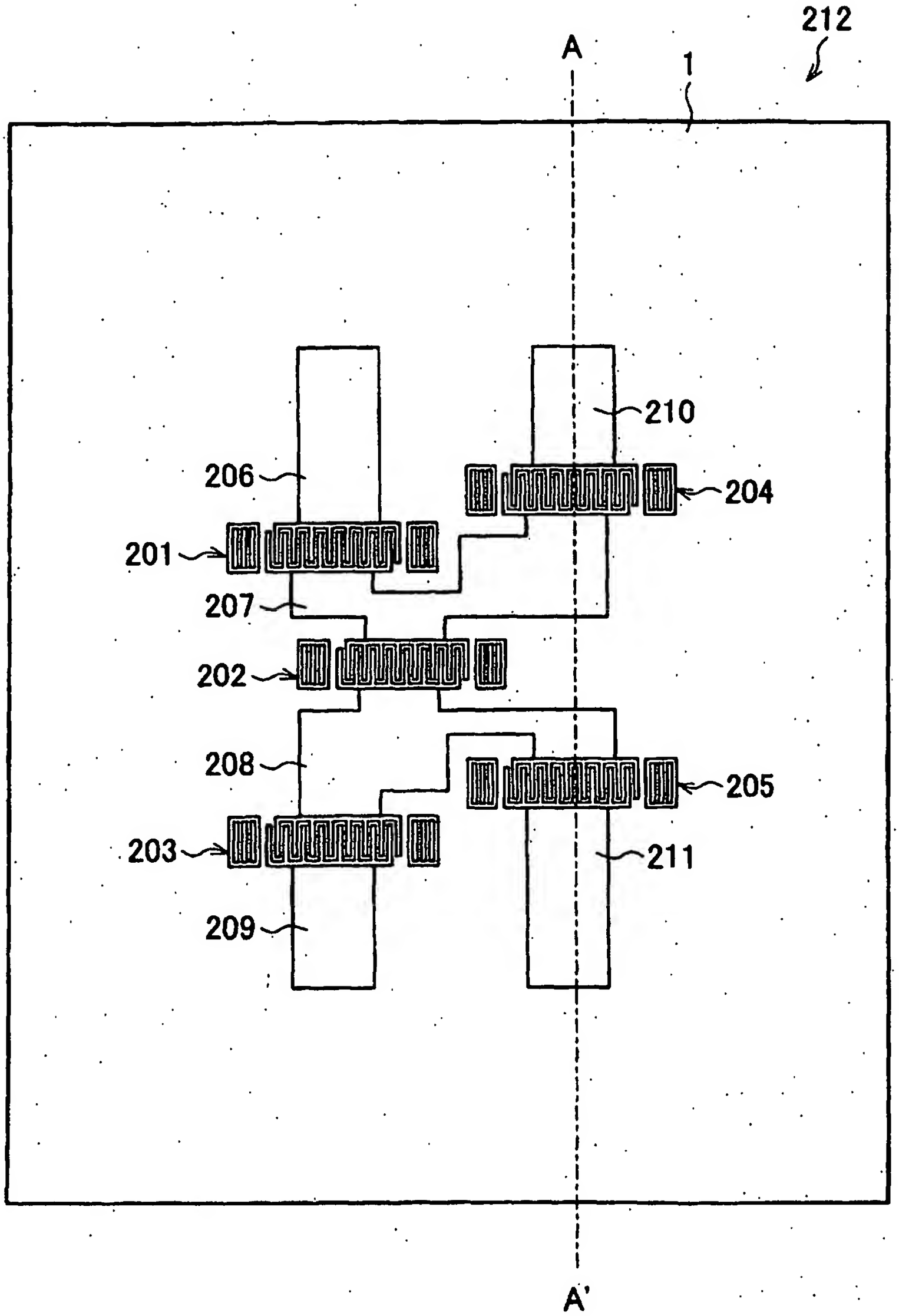


FIG. 11

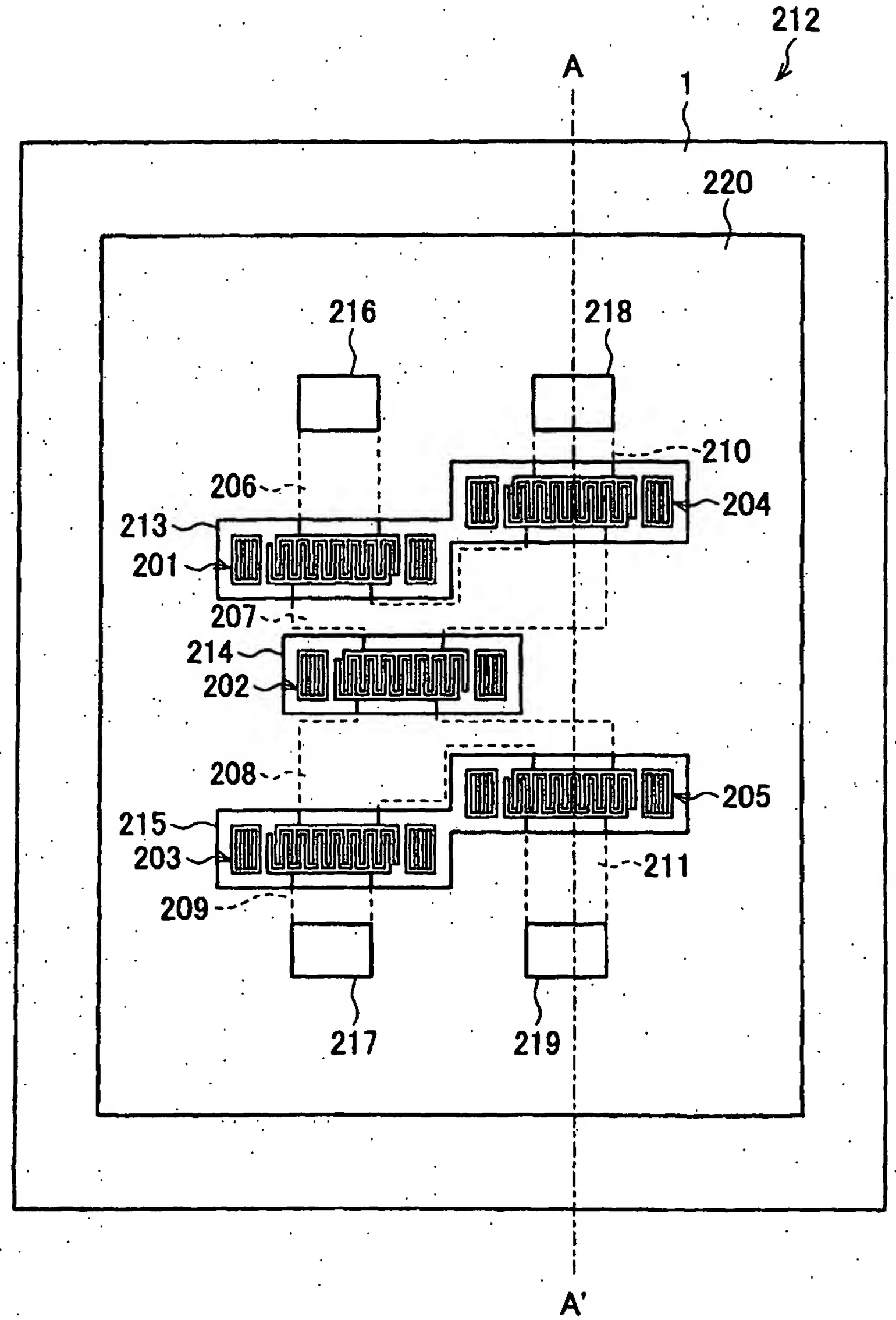

212
A
1
220
216
218
210
206
204
213
201
207
214
202
208
205
215
203
211
209
217
219
A'

FIG. 12

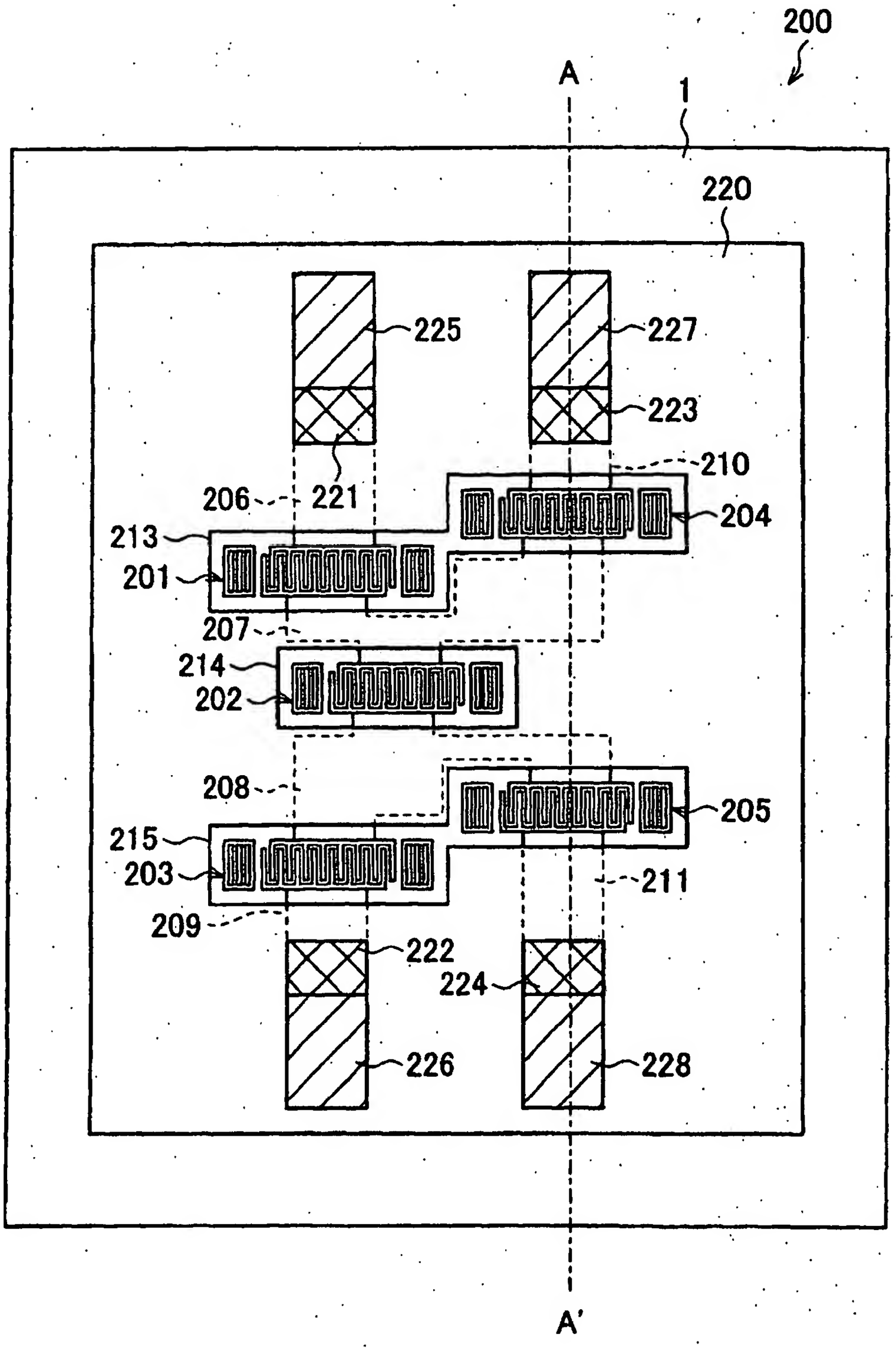

200
A
1
220
225
227
223
210
206
221
204
213
201
207
214
202
208
205
215
203
211
209
222
224
226
228
A'

FIG. 13

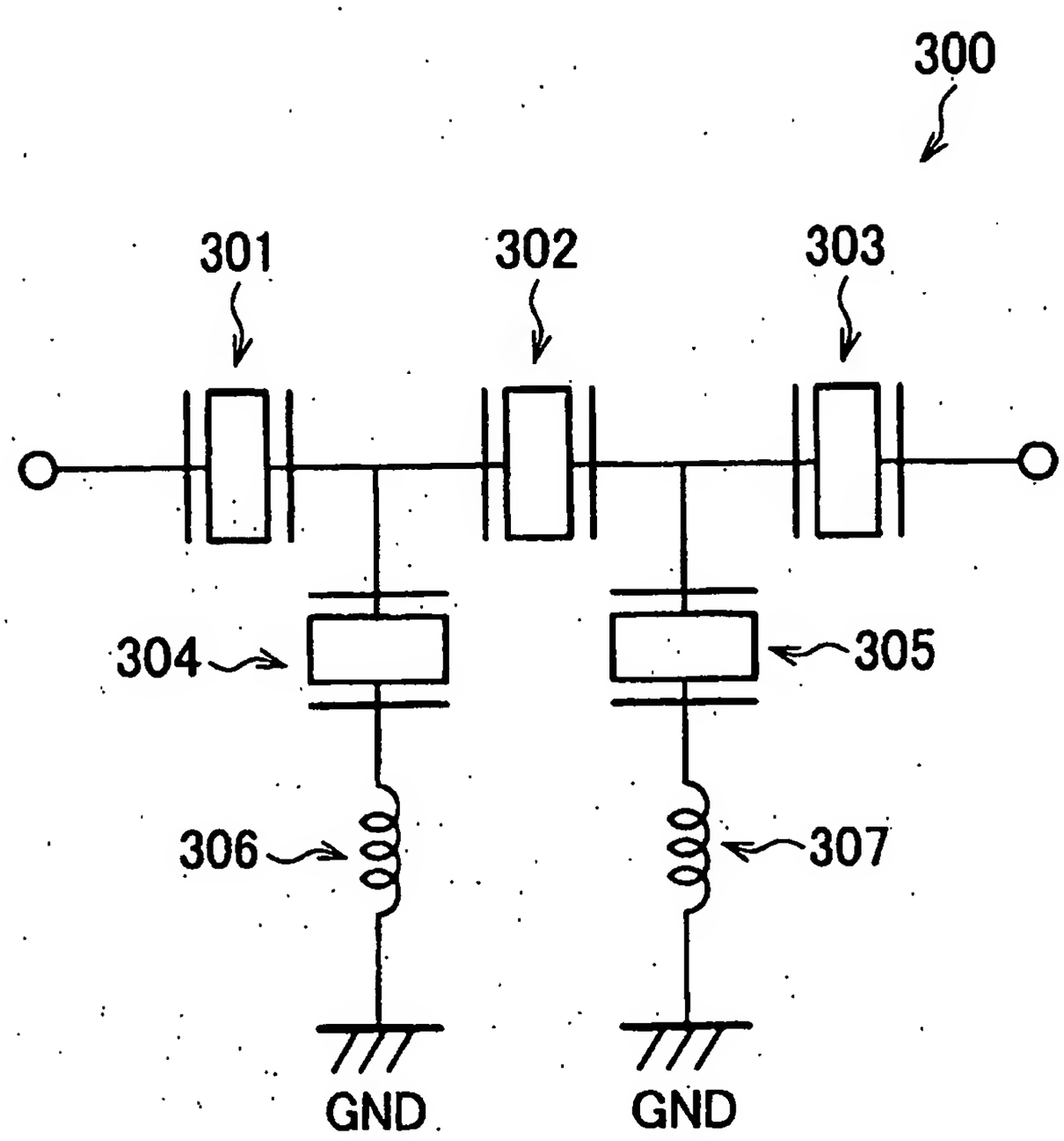


FIG. 14

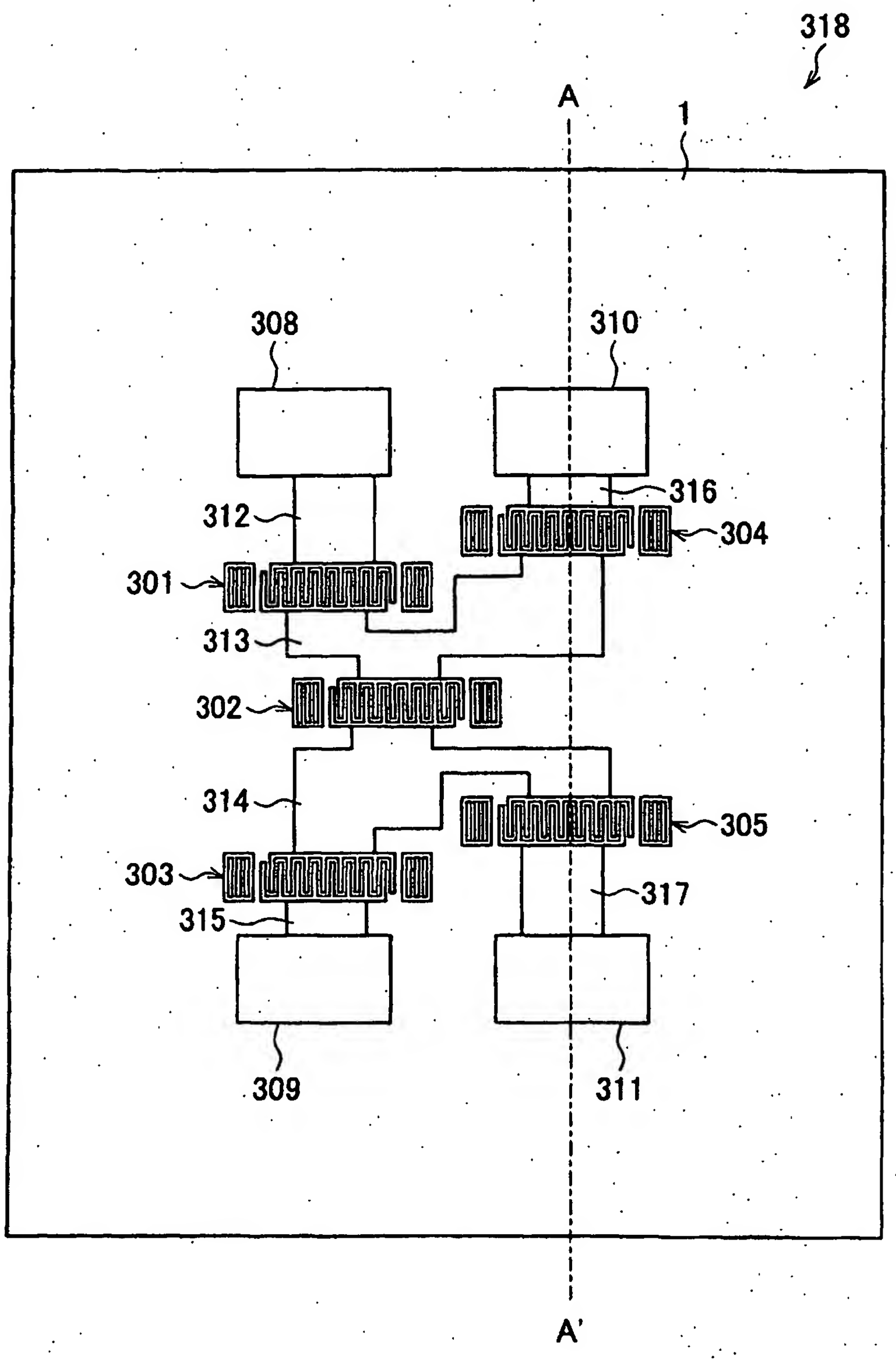

318
A
1
308
310
316
312
304
301
313
302
314
305
303
317
315
309
311
A'

FIG. 15

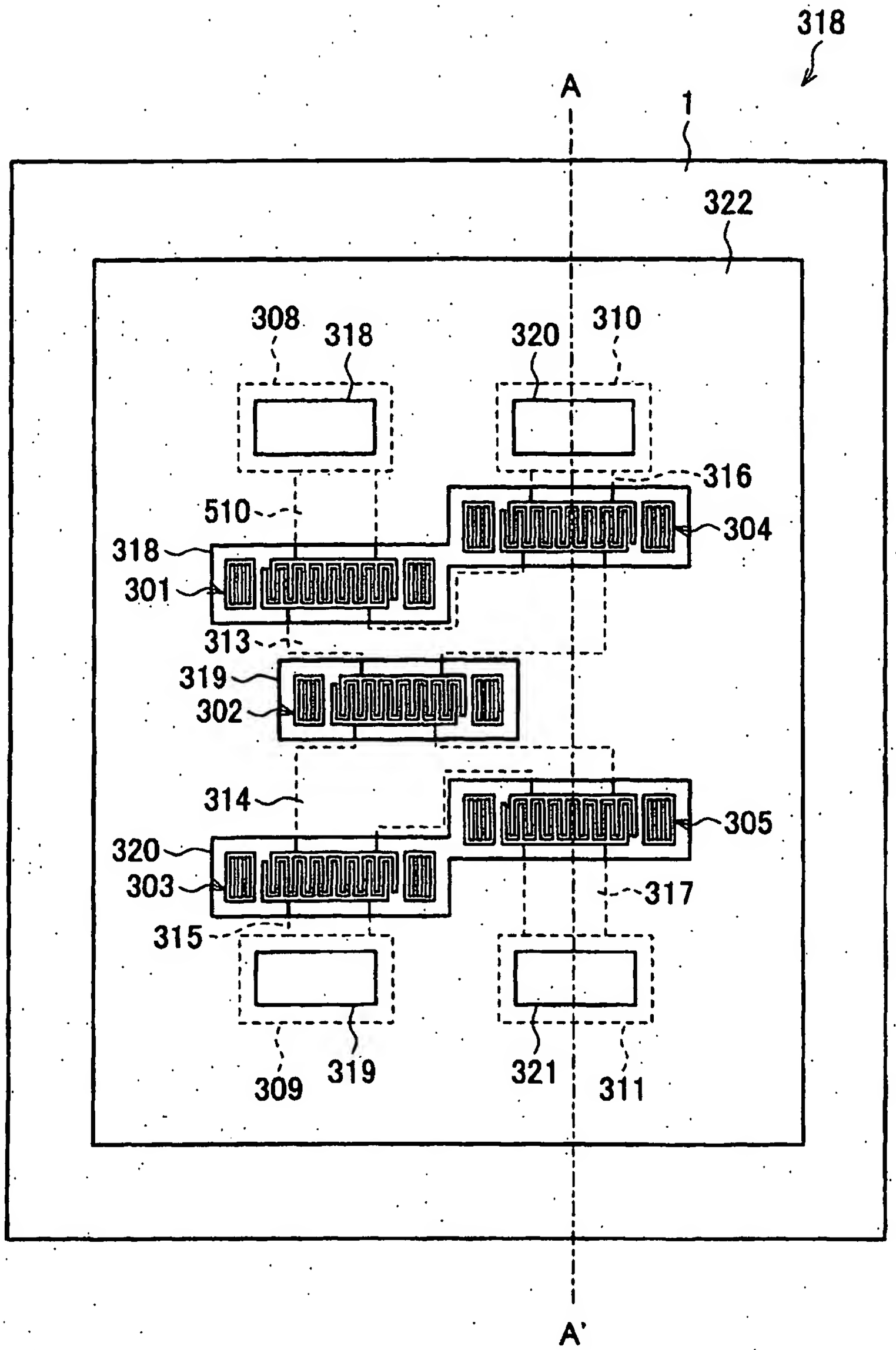

318
A
1
322
308
318
320
310
316
510
304
318
301
313
319
302
314
305
320
303
317
315
319
321
309
311
A'

FIG. 16

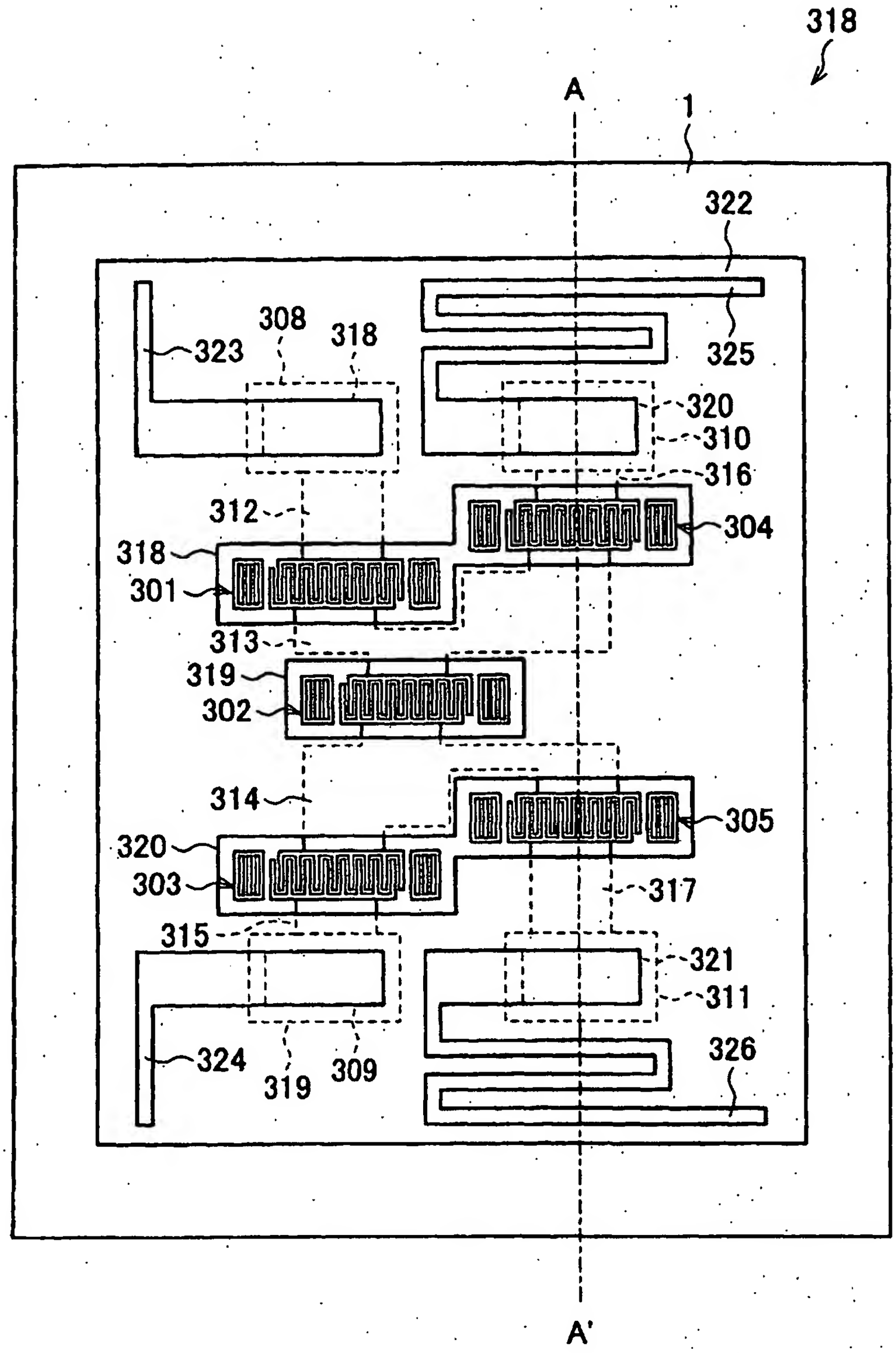

318
A
1
322
323
308
318
325
320
310
316
312
304
318
301
313
319
302
314
305
320
303
317
315
321
311
324
319
309
326
A'

FIG. 17

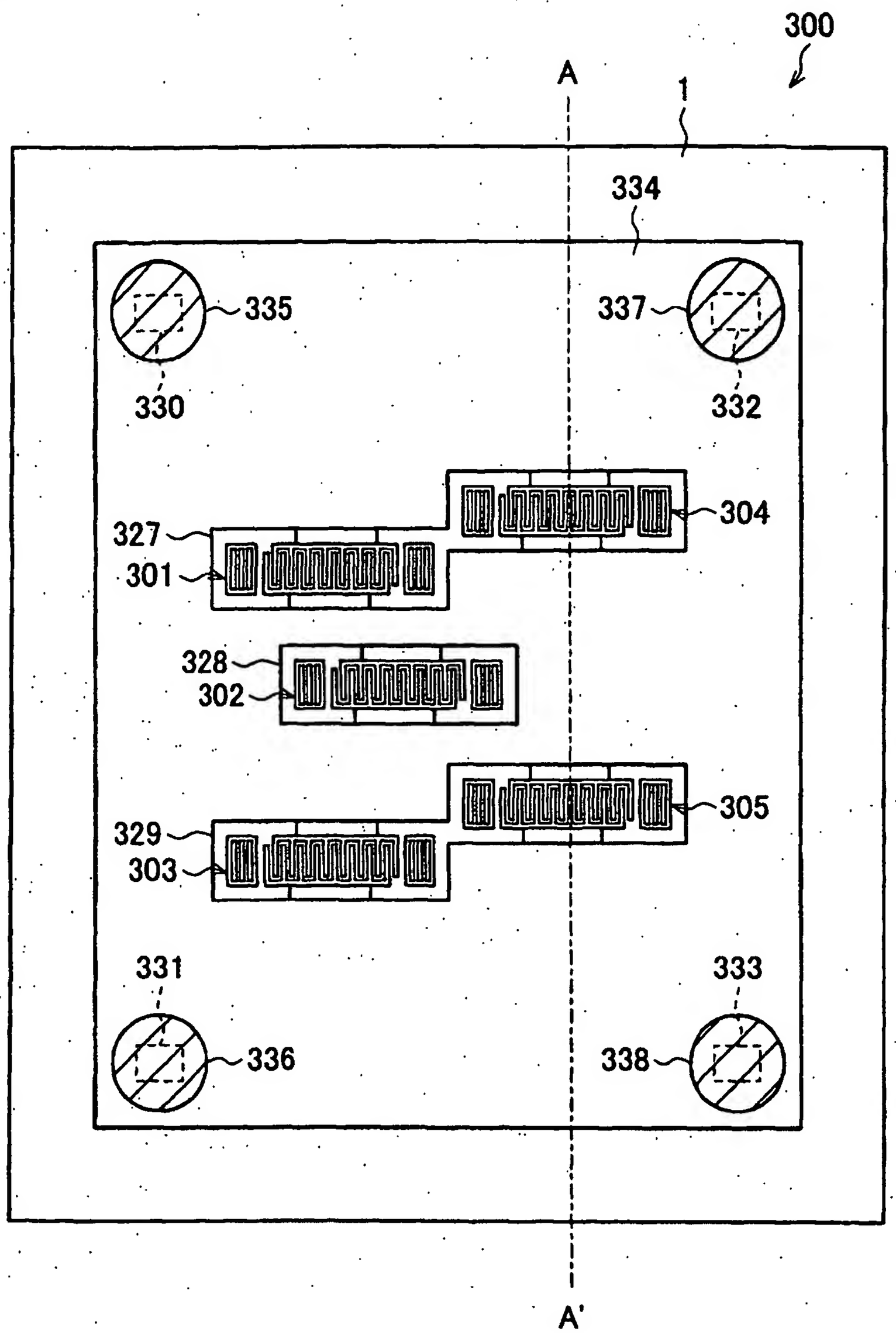

300
A
1
334
335
337
330
332
327
301
304
328
302
329
303
305
331
333
336
338
A'

FIG. 18

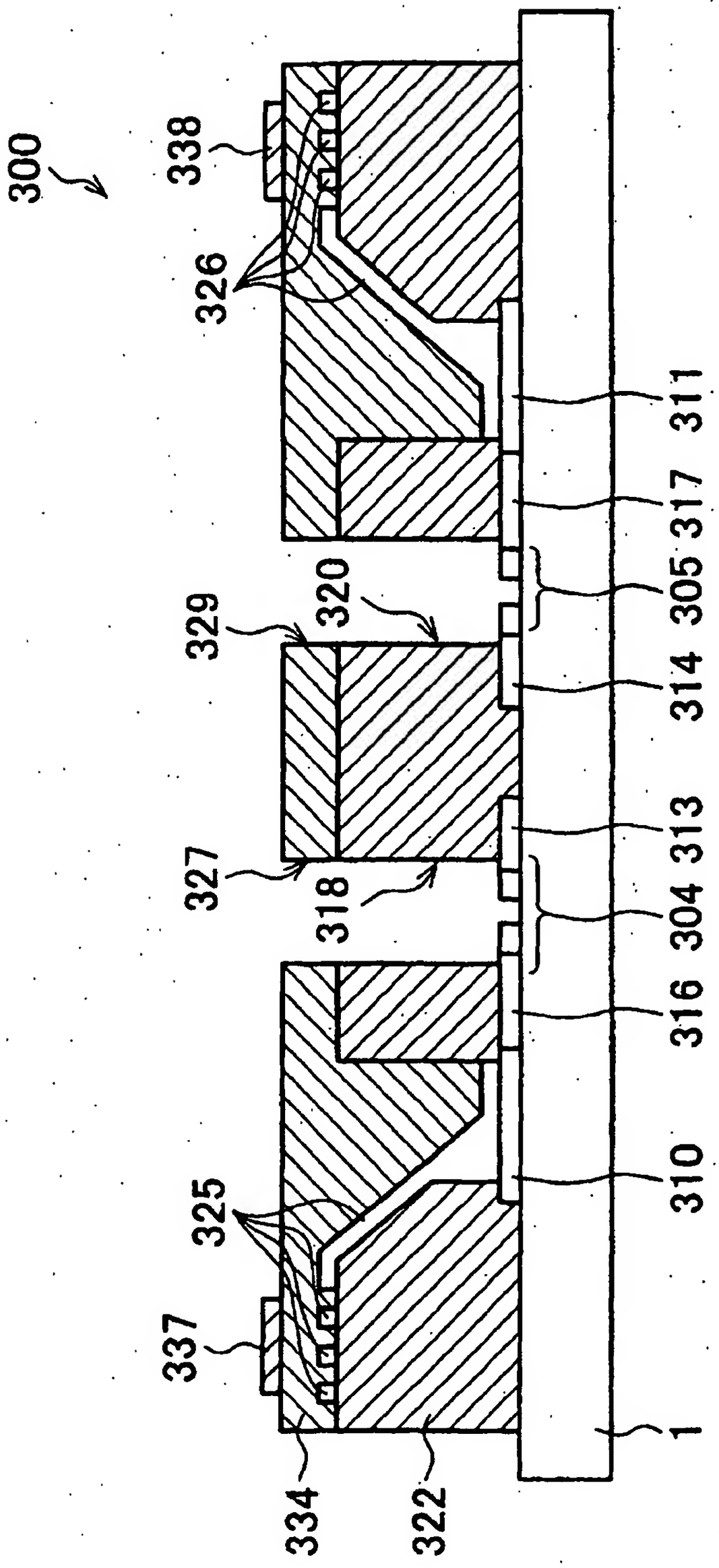

300
338
326
329
320
327
318
325
337
334
322
311
317
305
314
313
304
316
310
1

FIG. 19

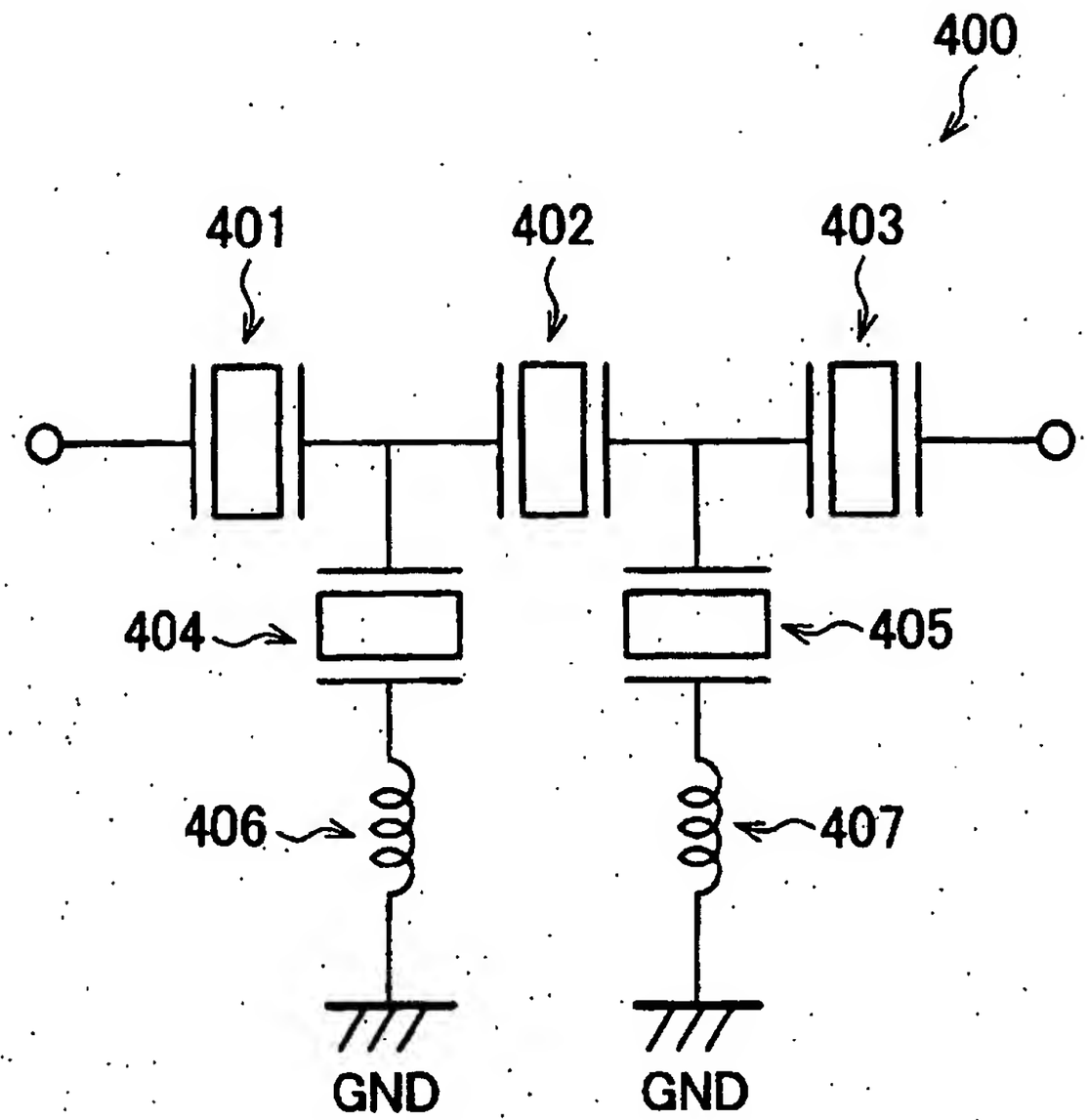


FIG. 20

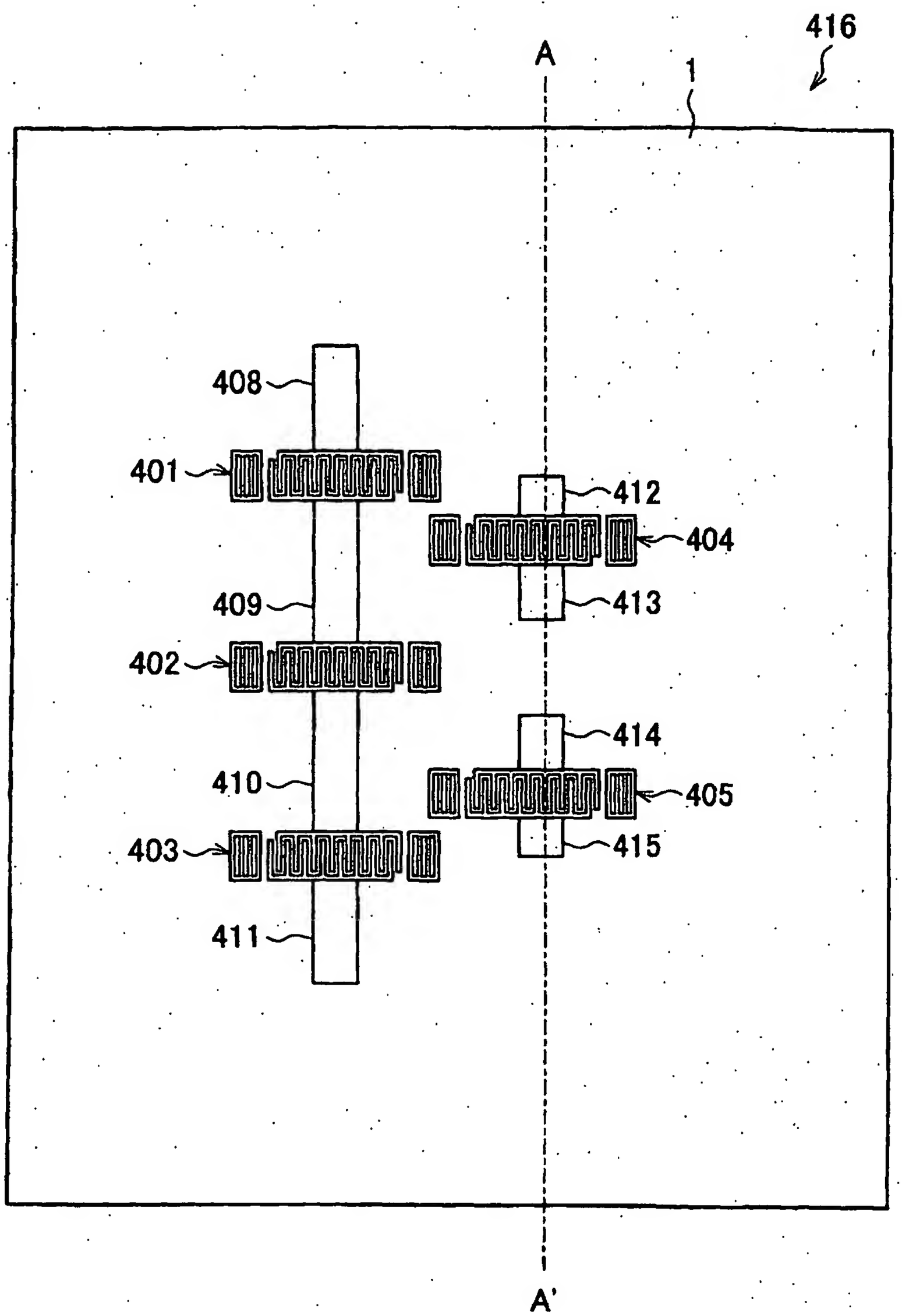


FIG. 21

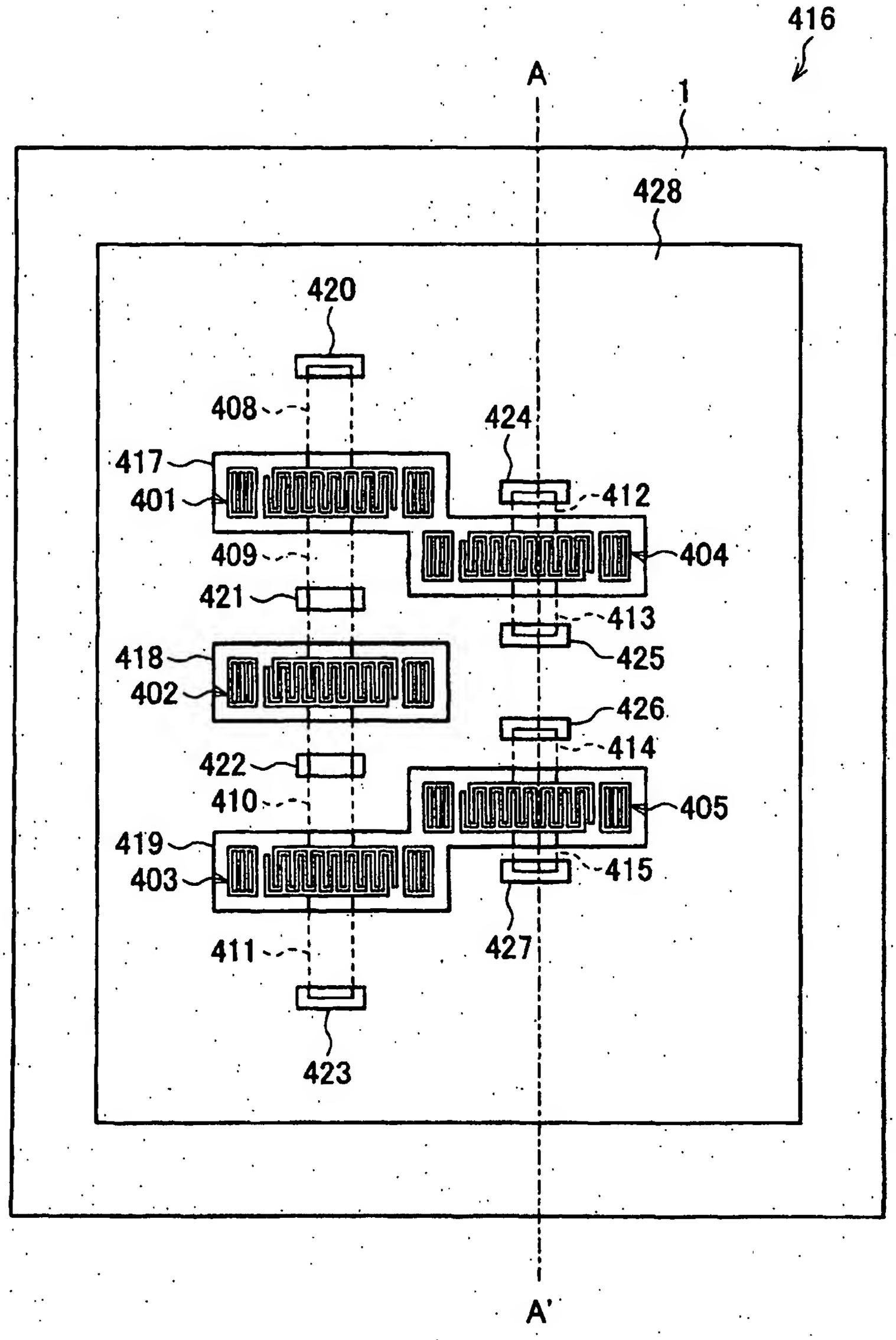

416
A
1
428
420
408
424
417
401
412
404
409
421
413
425
418
402
426
414
422
410
405
419
403
415
427
411
423
A'

FIG. 22

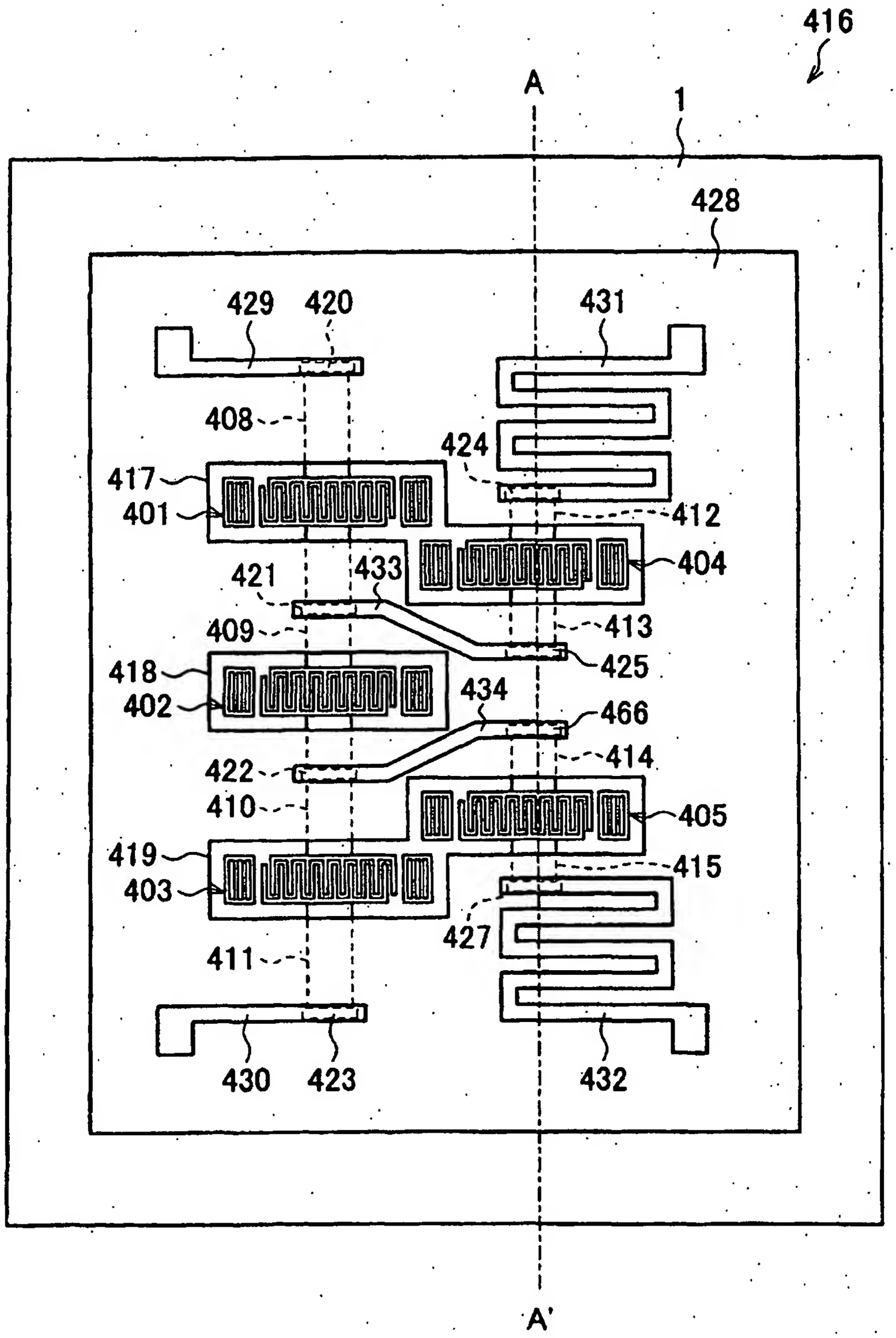

416
A
1
428
429
420
431
408
424
417
401
412
404
421
433
409
413
425
418
402
434
466
422
414
410
405
419
403
415
427
411
430
423
432
A'

FIG. 23

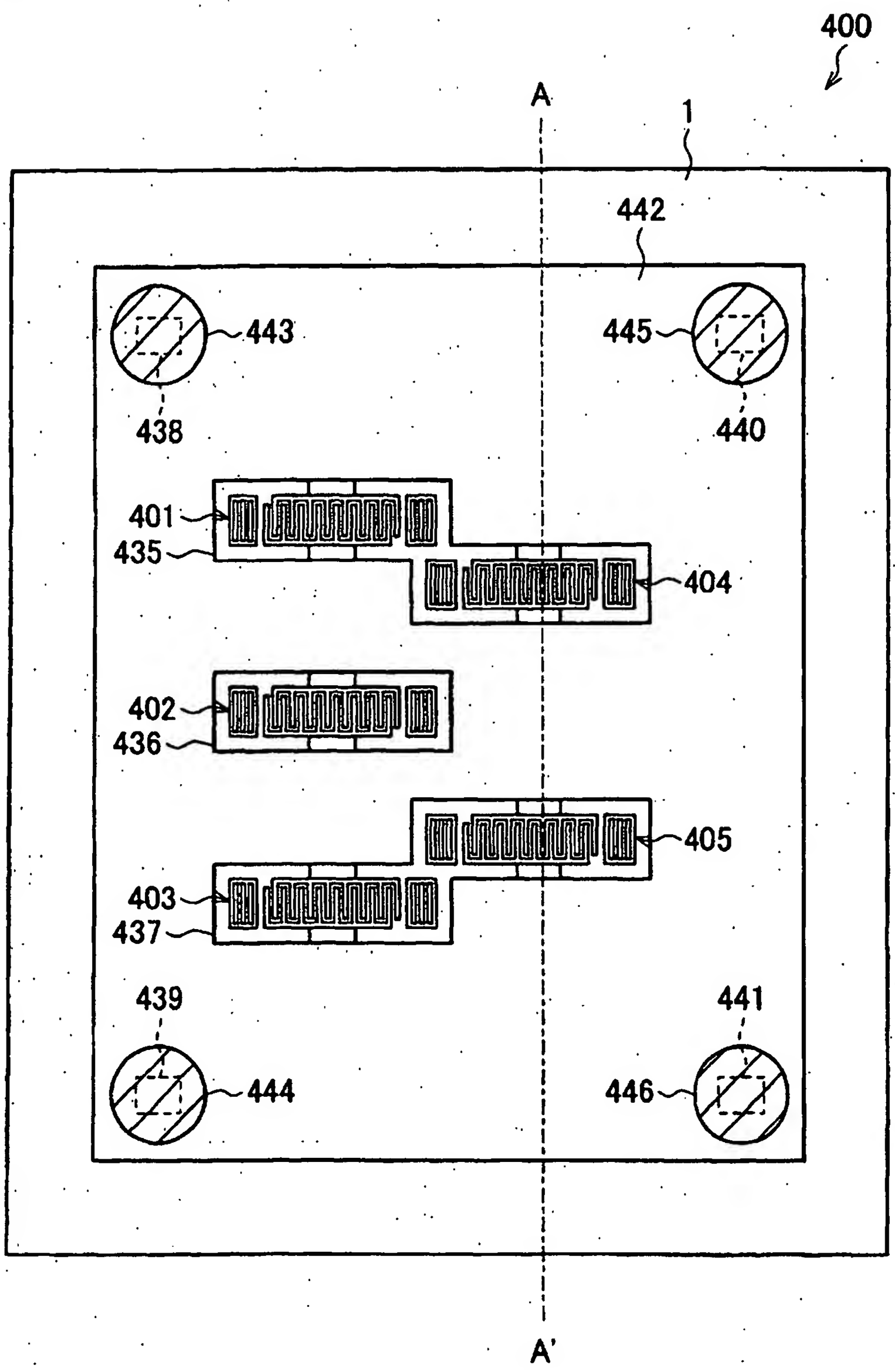
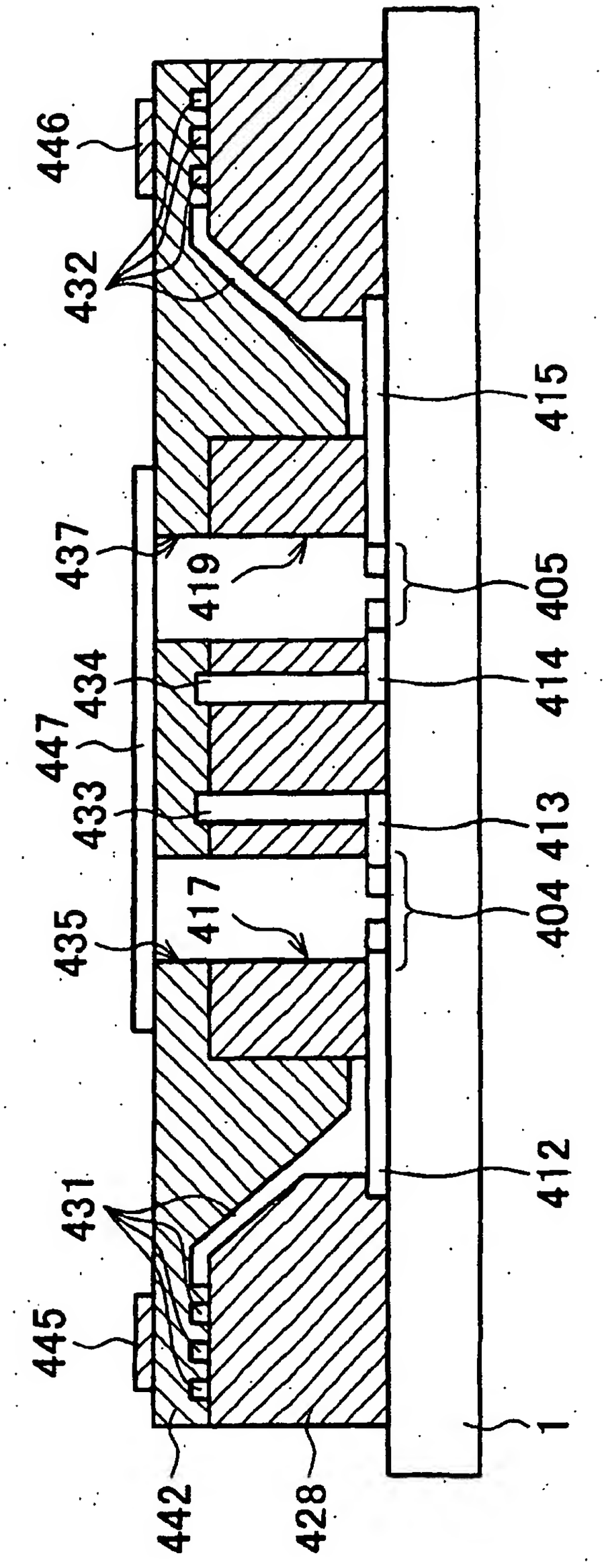

400
A
1
442
443
445
438
440
401
435
404
402
436
405
403
437
439
441
444
446
A'

FIG. 24


446
432
437
419
434
447
433
435
417
431
445
442
428
415
405
414
413
404
412
1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP03/09310

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] H03H9/25, H03H9/17, H03H3/02, H03H3/08

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] H03H9/25, H03H9/17, H03H3/02, H03H3/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Toroku Jitsuyo Shinan Koho	1994-2002
Kokai Jitsuyo Shinan Koho	1971-2002	Jitsuyo Shinan Toroku Koho	1996-2002

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 11-251866 A (TDK Corp.), 17 September, 1999 (17.09.99), & EP 939485 A1 & US 6181015 B1 & US 2001/0001293 A1	1,3,8
X	JP 2000-261285 A (Hitachi Media Electronics Co., Ltd.), 22 September, 2000 (22.09.00), (Family: none)	1,2,8,11-13
A	JP 2000-235979 A (Casio Computer Co., Ltd.), 29 August, 2000 (29.08.00), & TW 455959 B & CN 1264178 A	4-7,9,10, 14-18

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 August, 2003 (18.08.03)	02 September, 2003 (02.09.03)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1998)

European Patent Office
80298 MUNICH
GERMANY
Tel.: +49 89 2399 - 0
Fax: +49 89 2399 - 4465

Europäisches Patentamt | European Patent Office | Office européen des brevets

GROSSE BOCKHORNI SCHUMACHER
Patent- und Rechtsanwälte
Elsenheimerstrasse 49
80687 München
ALLEMAGNE

EPO Customer Services
Tel.: +31 (0)70 340 45 00

Date
14.08.07

Reference	Application No./Patent No.
E.85658EP(GS/K	04821283.1 - 2220 PCT/JP2004016857

Applicant/Proprietor
Toyo Communication Equipment Co., Ltd.

COMMUNICATION

The European Patent Office herewith transmits as an enclosure the supplementary European search report under Article 157(2)(a) EPC for the above-mentioned European patent application.

If applicable, copies of the documents cited in the European search report are attached.

☑ Additional set(s) of copies of the documents cited in the European search report is (are) enclosed as well.

Refund of the search fee

If applicable under Article 10 Rules relating to fees, a separate communication from the Receiving Section on the refund of the search fee will be sent later.

Europäisches Patentamt • European Patent Office • Office européen des brevets •

European Patent Office

SUPPLEMENTARY EUROPEAN SEARCH REPORT

Application Number
EP 04 82 1283

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	JP 2002 100945 A (TDK CORP) 5 April 2002 (2002-04-05) * abstract; figure 1 * -----	1-5	INV. H03H9/25
Y	EP 0 893 515 A1 (CRYSTAL TECH INC [US]) 27 January 1999 (1999-01-27) * abstract * * page 2, lines 44-57 * -----	1,2,4	
Y	WO 2004/002891 A (SILICON LIGHT MACHINES INC [US]) 8 January 2004 (2004-01-08) * abstract * * page 1, line 10 - page 3, line 3 * -----	3	
Y	JP 06 305895 A (HITACHI METALS LTD) 1 November 1994 (1994-11-01) * abstract * * paragraph [0002] * -----	3	
P,Y	EP 1 443 643 A (MURATA MANUFACTURING CO [JP]) 4 August 2004 (2004-08-04) * figure 1 * * paragraphs [0043] - [0051] * -----	5	

TECHNICAL FIELDS SEARCHED (IPC)

H03H
C30B

The supplementary search report has been based on the last set of claims valid and available at the start of the search.

Place of search	Date of completion of the search	Examiner
Munich	2 August 2007	Unterberger, Michael

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C04)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 04 82 1283

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

02-08-2007

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2002100945 A	05-04-2002	NONE	
EP 0893515 A1	27-01-1999	DE 69819971 D1	08-01-2004
		DE 69819971 T2	02-09-2004
		JP 11092147 A	06-04-1999
		US 6319430 B1	20-11-2001
WO 2004002891 A	08-01-2004	AU 2003232441 A1	19-01-2004
		CN 1678531 A	05-10-2005
		EP 1534633 A1	01-06-2005
		JP 3816903 B2	30-08-2006
		JP 2004035396 A	05-02-2004
		TW 234303 B	11-06-2005
		US 2005201926 A1	15-09-2005
		US 2005214469 A1	29-09-2005
		US 2004163596 A1	26-08-2004
JP 6305895 A	01-11-1994	NONE	
EP 1443643 A	04-08-2004	AU 2003252239 A1	16-02-2004
		CN 1557049 A	22-12-2004
		WO 2004012332 A1	05-02-2004
		JP 2004129224 A	22-04-2004
		US 2004174090 A1	09-09-2004